Date of Issue: July: 1989

Service Manual

IVAC(R) VITAL•CHECK(R) Vital Signs Measurement System - Model 4200

PATENT INFORMATION

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REVISION/CHANGE RECORD PAGE

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7/89	A	Pm	Original Issue

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CHAPTER ONE - GENERAL INFORMATION

1.0 INTRODUCTION

This publication represents the original issue of the service manual for the IVAC VITAL•CHECK® Vital Signs Measurement System - Model 4200. (See figure 1-1.) This section contains information for use in maintaining and servicing the instrument and is written for personnel experienced in analyzing, troubleshooting, and repairing analog and digital microprocessor-based electronic equipment.

NOTE: Model 4200C instruments are compatible with the IVAC Computer Interface Module (CIM). For instructions on using the Model 4200C instrument equipped with CIM, refer to the CIM II Directions For Use.

1.1 FEATURES

This is a microprocessor-based electronic instrument specifically designed to measure and display a patient's systolic and diastolic blood pressures (BP), pulse rate, and temperature.

Among the many features of the instrument are:

- LED readouts for digitally displaying the systolic and diastolic BP, pulse rate, and temperature.
- BP determined by: auscultation (primary method) or oscillometry (secondary method).
- Selection of four different initial cuff inflation pressures (100, 125, 150, and 200 mmHg).
- Automatically initiated repetitive BP measurements at preset intervals of 1, 2.5, 5, 15, and 30 minutes.
- Automatic reinflation and measurement of BP in cases of artifact, unusually high pressures, or low signal.
- Reads BP up to 275 mmHg systolic, and down to 20 mmHg diastolic.
- Choice of cuff sizes: small child, child, adult, and large adult cuffs.
- A systolic mode allowing continuous, systolic-only, measurements for a 5 minute period.
- Audible tones to indicate when new BP measurements have been determined and are being displayed, and also when temperature computation is completed (in normal mode).

- Eight character information display; messages indicate operational prompts and error diagnostics.
- Choice of Celsius or Fahrenheit temperature displays via °F/°C internal DIP switch at front panel overhang.
- Two modes of temperature measurement: normal and monitor (continuous monitoring).
- Oral and rectal thermometer probes.
- The stand provides a storage space for the cuff and probe covers.
- Pulse irregularity indication (three dots in PULSE display).
- Operates on AC or self-contained battery power.

1.2 PHYSICAL DESCRIPTION

This instrument is designed to measure and display blood pressures (BP), pulse rate, and patient's temperatures and may be operated on either AC or battery power. It provides alphanumeric displays showing information such as patient's systolic or diastolic BP, pulse, and temperature, as well as BP function information display and error messages regarding the state of the instrument.

The instrument weighs 5.897 kg (13 lb) and is housed in a white case with a dark grey front panel. The built-in handle allows the instrument to be easily carried from one area to another (when writing table is not installed). For more portability, the instrument is specifically designed to be used with the IVAC Vital Signs Instrument Stand - Model 1042, which has storage space for cuffs and probe covers, as well as cord wrap storage.

The instrument display panel contains several touch switches: the PRES. SELECT switch, to select mmHg initial cuff inflation pressure; the MODE SELECT switch, to select desired operating mode; the DISPLAY TEST switch, allowing the thermometer to enter the calibration mode and also to initiate a display test; the ON/OFF switch, to apply power to and from the instrument; the START/STOP switch, to initiate a measurement cycle or to terminate a cycle in progress; the NORMAL/MONITOR Mode switch, to select mode for temperature measurement; and the CHARGE indicator, indicating AC or battery power.

For more detailed descriptions of instrument display controls and indicators, BP function information display and error messages see Chapter Two (tables 2-1, 2-2, and 2-3, respectively).

For instrument specifications and features refer to table 1-1 of this chapter.

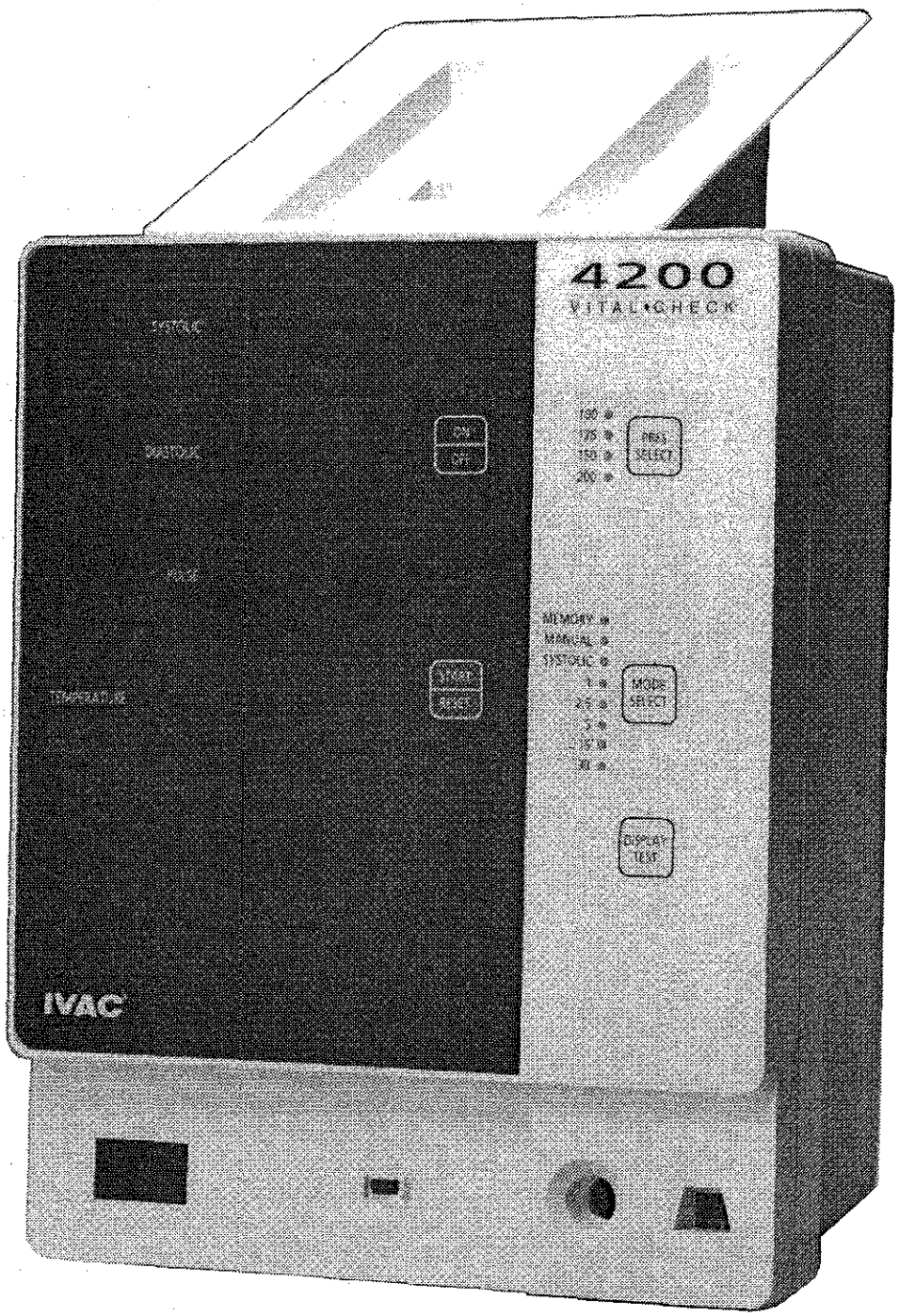

Figure 1-1. VITAL•CHECK Instrument - Model 4200

Table 1-1. Specifications and Features

Features	Specifications
Power requirements	
• AC	95-135 VAC, 50/60 Hz, 0.65A, 3-wire grounded system.
• DC	Internal rechargeable sealed lead-acid battery pack: output voltage 12.0 VDC; capacity 2.5 Ah. A discharged pack is automatically charged whenever AC power is present; to 70% full charge in 3 hours when instrument is not operating; and 70% full charge in 5 hours when instrument is operating. A full charge will occur in 12-16 hours. A new fully-charged battery will operate the instrument for 2.5 hours or 150 BP measurements (whichever comes first).
Measurement Range	
• BP	20-275 mmHg with 1 mmHg resolution. (Transducer accuracy is ±3 mmHg or ±2% of reading, whichever is greater.)
• Pulse Rate	20-200 Beats/minute.
• Temperature	Normal mode: 32.2°C to 42.1°C ±0.1°C (90.0°F to 107.9°F ±0.2°F). Monitor mode: 31.1°C to 42.1°C ±0.1°C (88.0°F to 107.9°F ±0.2°F).
Upper Limit Operating Range	Normal Operation: 290 mmHg.
Inflation Time Too Long	Normal Operation: 4 Minutes (Software controlled -- accumulative).
Cuff Inflation Rate	20-40 mmHg/sec.

Cuff Deflation Rate	
• Normal	4-6 mmHg/sec.
• For Retries	2-3 mmHg/sec.
Accuracy	
• BP	Meets ANSI/AAMI SP-10-1987, American National Standard for Electronic or Automatic Sphygmomanometer (when tested with adult cuff).
• Temperature	+/-0.1°C, +/-0.2°F (when tested in a calibrated water bath).
Failsafe Cuff Pressures	
• Software	$\leq$ 320 mmHg (Normal operating mode - FIX ME "5").
• Electrical	330-335 mmHg (Normal/calibration mode).
• Mechanical	375-405 mmHg (Normal/calibration mode).
Failsafe Cuff Inflation Time	4.5 Minutes.
Failsafe Cuff Deflation Rate	300 to 20 mmHg in 3 seconds or less.
Dimensions	
• Length	20.32 cm (8 in.).
• Width	22.10 cm (8.7 in.).
• Height	33.02 cm (13 in.).
Weight	5.897 kg (13 lb).

Environment

• Temperature	Storage: -30°F to 149°F.
	Operating:
	60°F to 110°F (blood pressure system).
	60°F to 110°F (thermometer system; room ambient - monitor mode).
	60°F to 94°F (thermometer tip temperature - normal mode).
	60°F to 86°F (thermometer system, room ambient - normal mode, battery operation).
	60°F to 84°F (thermometer room ambient - normal mode, AC operation).
• Humidity	Storage and Operating: 15-95%; Relative humidity, noncondensing.
• Shock	30G for 11 msec on any axis.
• Vibration	In Shipping Carton: 2 hours in each of 3 axes; 5-50 Hz over a 2 minute period at 5G maximum.

1.3 DEFINITION OF TERMS

The definitions of certain terms and concepts used throughout this manual are listed below.

a. NOTE: Indicates important explanatory or parenthetical material as a reference to assist the user.

b. CAUTION: Indicates important explanatory information which, if not followed, can result in extensive damage to equipment.

c. WARNING: Indicates important explanatory information which, if not followed, can result in personal injury.

Reference designations and abbreviations are listed in table 1-2 as a reference for common technical terms used within service manuals.

1.4 ACCESSORIES

a. Accessory Holder - (figure 1-2). The accessory holder, which is an integral part of the IVAC Vital Signs Instrument Stand - Model 1042, is designed to provide convenient storage space for cuff and probe covers when they are not in use, as well as cord wrap storage.

b. IVAC Standard Probes - Models 1880L Oral (blue, long cord) and 1882L Rectal (red, long cord) (figure 1-3). The Model 1880L/1882L probe contains a heat-sensing thermistor located inside a plastic shaft. Both models are electronically identical. The thermistor provides a temperature-proportional resistance to the thermometer through the probe connection and flexible 14-inch coil cord attached to the base of the probe shaft. Also located at the base of the probe is an ejection button for easy disposal of used probe covers. These probes are designed to be used in either the normal or monitor mode of operation. All utilize IVAC Probe Covers - Model 850.

c. IVAC Probe Covers - Model 850 (figure 1-3). The probe cover is a thin plastic sheath with thermal characteristics carefully selected to match the requirements of the VITAL•CHECK instrument. The probe cover is used to cover the shaft of the probe to prevent cross-contamination or infection during temperature measurement.

NOTE: IVAC cannot guarantee proper fitting of covers, accuracy of temperature readings, or the overall functions of its thermometer when using probe covers that are not IVAC products.

d. IVAC Adult Size BP Cuff - Model 1148 (figure 1-5). The cuff wraps as a standard BP cuff and fits arms in the size range 27.9 to 41.7 cm.

e. IVAC Large Adult Size BP Cuff - Model 1149 (figure 1-5). Identical in form and function to the Model 1148 cuff, but designed to fit arms in the size range of 33.0 to 50.8 cm.

f. IVAC Child Size BP Cuff - Model 1147 (figure 1-5). Identical in form and function to the Model 1148 cuff, but designed to fit child size arms in the size range of 19.6 to 28.7 cm.

g. IVAC Vital Signs (VS) Instrument Stand - Model 1042 (figure 1-4). This stand is specifically designed to accommodate the VITAL•CHECK instrument - Model 4200. It has a low center of gravity and rolling casters for easy maneuverability from one area to another. The saddle-bag design provides a convenient storage place for cuff and probe covers when not in use, as well as cord wrap storage. (When ordering parts for the instrument stand assembly, refer to Chapter Eight (ILLUSTRATED PARTS BREAKDOWN) of this manual.)

h. IVAC Thermometer Tester - Model 828A (figure 1-6). The thermometer tester confirms in a few seconds that the VITAL•CHECK instrument thermometer function is calibrated by displaying either 98.6°F or 37°C, depending on the setting of the S2 internal DIP switch no. 5 (°F/°C), located at the bottom, right-hand side of the instrument at front panel overhang (figure 2-2).

i. Umbilical Cable (6 ft) - Model 1131 (figure 1-7). The umbilical cable consists of a flexible air hose and a coaxial cable and microphone for connection between the cuff and the VITAL•CHECK instrument. The air hose is used to deliver air to inflate the cuff, and the coaxial cable and microphone deliver Korotkoff signals to the instrument.

j. Umbilical Cable (12 ft) - Model 1132 (figure 1-7). Same in form and function as the Model 1131 but is 12 feet long.

k. Writing Table - PN 131298 (figure 1-8). A plastic table which attaches to the top of the VITAL•CHECK instrument to assist users in note taking.

l. Writing Table Note Pads (5 Tablets) - PN 127335 (figure 1-8). Note pads for use with the Writing Table - PN 131298, which provide the user with a quick chart to record patient information such as: room number, patient name, blood pressure, pulse, respiration, and temperature.

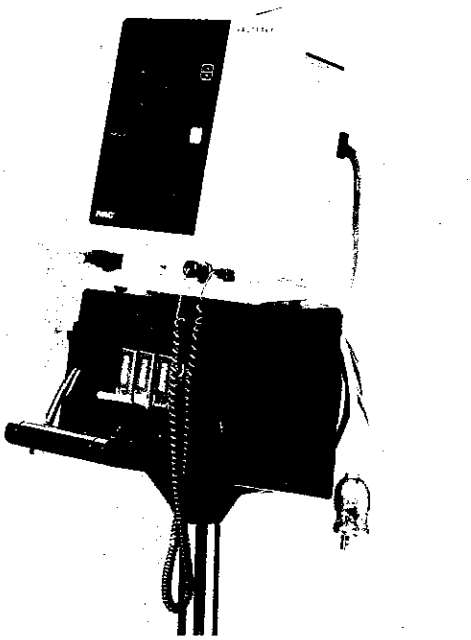

Figure 1-2. Accessory Holder

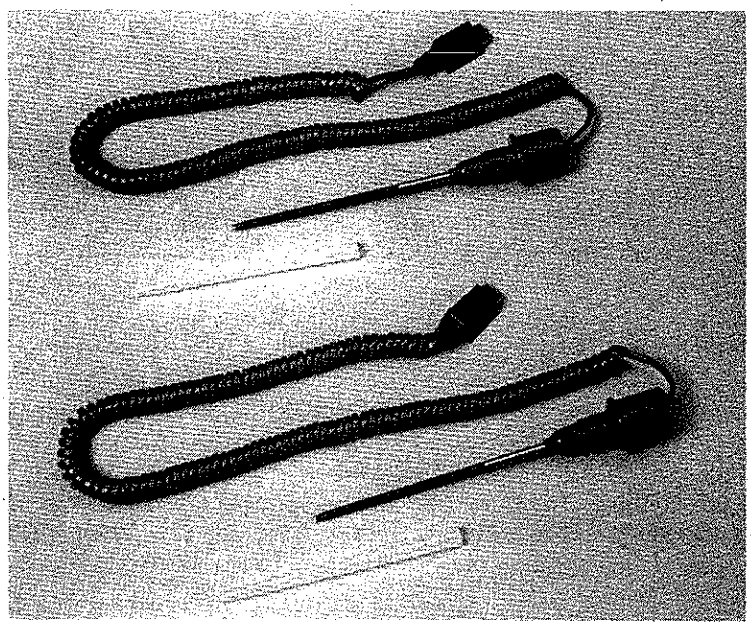

Figure 1-3. IVAC Standard (Long) Probes (1880L, 1882L) and Probe Covers (850)

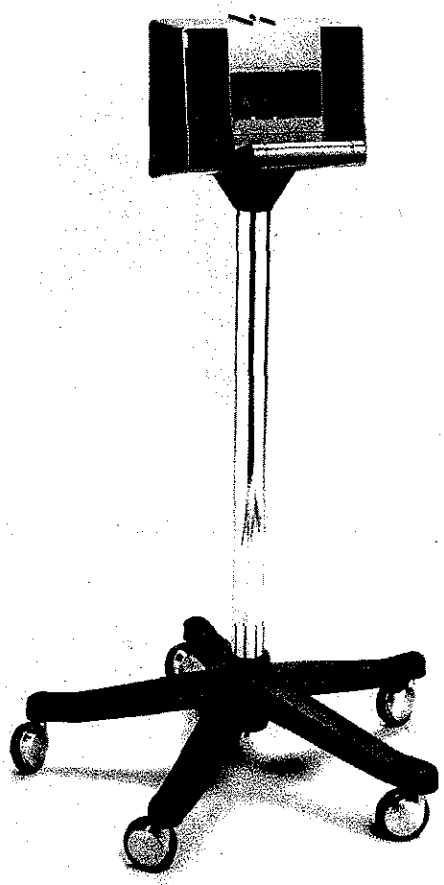

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Figure 1-4. IVAC Vital Signs Instrument Stand (Model 1042)

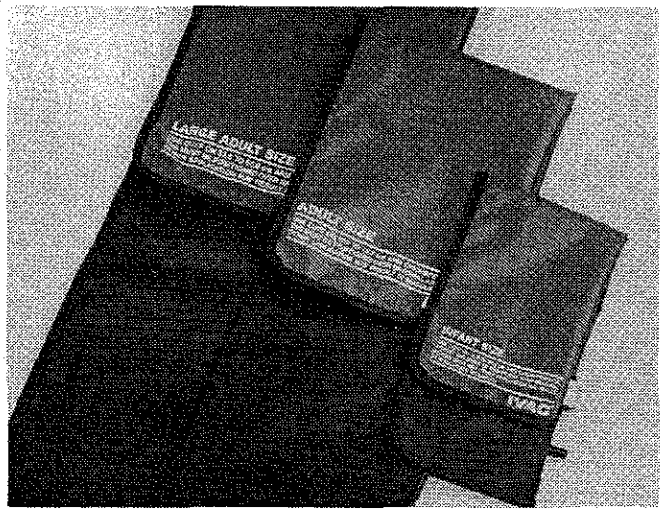

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Figure 1-5. IVAC Blood Pressure Cuffs (1147, 1148, 1149)

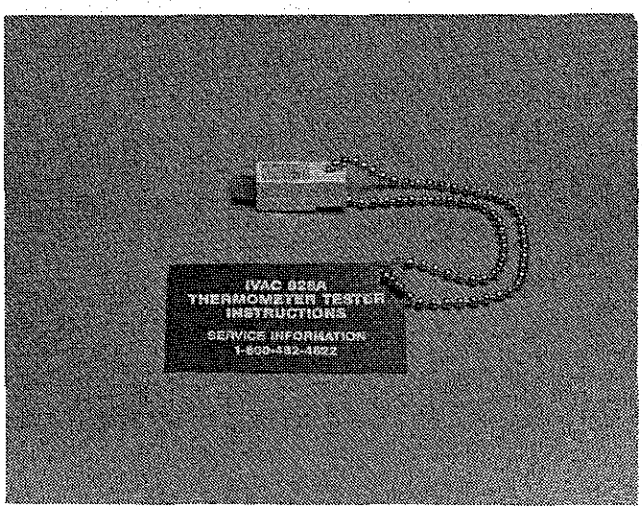

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Figure 1-6. IVAC Thermometer Tester (828A)

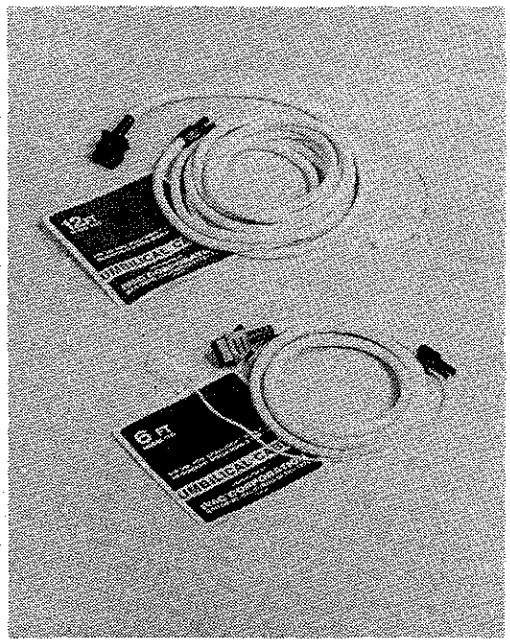

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Figure 1-7. Umbilical Cables (1131 or 1132)
(6 and 12 ft lengths)

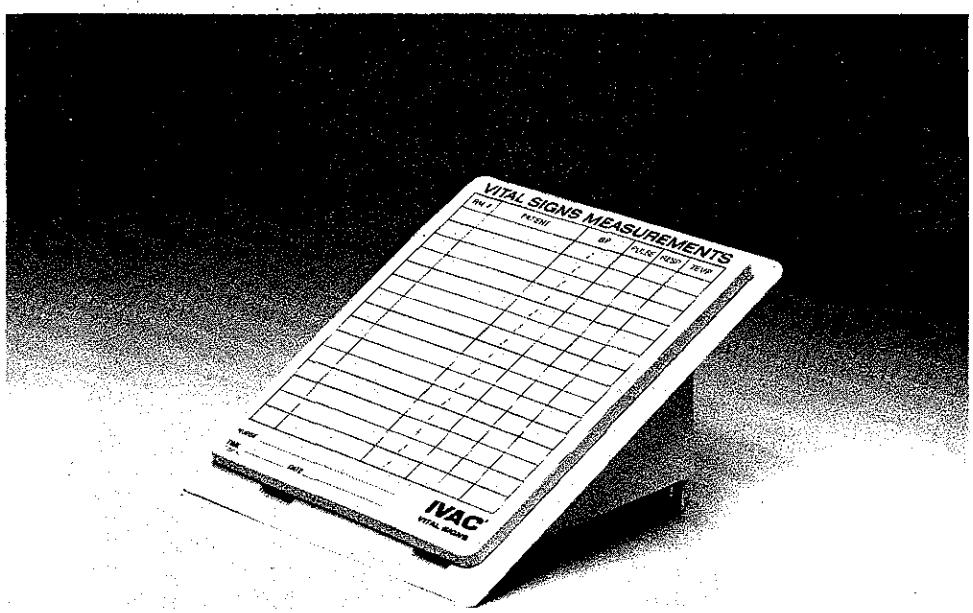

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Figure 1-8. Writing Table with Note Pads

Table 1-2. Reference Designations and Abbreviations

Reference Designation	Definition
C	capacitor
CR	diode
DS	display
F	fuse
J	connector on printed wiring board, terminal header
L	inductor
LS	speaker
P	pressure transducer
Q	transistor
R	resistor
RN	resistor network
S	switch
TP	test point
U	integrated circuit
VR	zener diode, voltage reference diode, or voltage regulating integrated circuit
X ___	socket for electronic component (the designation for the component appears in the blank space)
XP, XU	socket for integrated circuit
Y	crystal

Abbreviation	Definition
A	ampere
AC	alternating current
A/D	analog to digital
Ah	ampere-hour
A/R	as required
cm	centimeter
COML	commercial
CMOS	complementary metal-oxide semiconductor
CPU	central processing unit
°C	degrees Celsius
D/A	digital to analog
DC	direct current
dia	diameter
DIP	dual in-line package
EPROM	erasable programmable read-only memory
ft	foot; feet
F	farad
°F	degrees Fahrenheit
FET	field-effect transistor
gm	gram

>	greater than
<	less than
hex	hexadecimal, hexagonal
Hg	mercury
hr	hour
Hz	hertz
IC	integrated circuit
ID	inside diameter
in.	inch
I/O	input/output
IV	intravenous
kg	kilogram
kHz	kilohertz
kΩ	kilohm
kV	kilovolt
KVO	keep vein open
kW	kilowatt
lb	pound(s)
LED	light emitting diode
M	mega
MAP	mean arterial pressure
mcg	microgram
MHz	megahertz
MΩ	megohm
μamp	microamp
μF	microfarad
μP	microprocessor
μsec	microsecond
m	milli
mA	milliampere
ml	milliliter
mm	millimeter
mmHg	millimeters of mercury
ml/hr; ml per hr	milliliters per hour
msec	millisecond
min	minute
MOS	metal-oxide semiconductor
MUX	digital multiplex
n	nano
N/A	not applicable
no; nos.	number; numbers
NPN	negative-positive-negative
nsec	nanosecond
Ω	ohm
OD	outside diameter
p	pico
PCB	printed circuit board
pF	picofarad
P/N	part number
PNP	positive-negative-positive
PR	power regulator
psi	pounds per square inch

psig	pounds per square inch-gauge
pw	printed wiring
RAM	random-access memory
rms	root mean square
ROM	read-only memory
RPS	relative pressure signal
SCR	silicon controlled rectifier
sec	second
SIP	single in-line package
S/N	serial number
TTL	transistor-transistor logic
V	volt(s)
VAC	volts alternating current
VDC	volts direct current
Vrms	volts root mean square
VTBI	volume to be infused
W	watt
x	by; times (mathematical)

CHAPTER TWO - OPERATION

2.0 INTRODUCTION

The IVAC VITAL•CHECK Vital Signs Measurement System - Model 4200 is a microprocessor-based electronic instrument specifically designed to measure and display a patient's systolic and diastolic blood pressure (BP), pulse rate, and temperature. This chapter describes the operation and functional checkout and inspection procedures required for the instrument, as well as correct storing and cleaning methods. Operating instructions are included for testing purposes only.

2.1 INITIAL SETUP

a. Carefully unpack the instrument and its accessories, and ensure that each item is undamaged.

b. Set the S2 internal DIP switch (no. 5) for °F/°C:

   1. Lay the instrument down on its back panel to access the right-hand louvers located at front panel overhang (figure 2-2).

   2. Using a non-metallic tool (i.e., wooden end of Q-tip), place the internal DIP switch (no.5) to the "up" position for degrees Fahrenheit or "down" for degrees Celsius, as desired. (See figure 2-2.)

   3. Return instrument back to upright position.

c. Attach the instrument to an IVAC Model 1042 instrument stand by placing the threaded opening at bottom center of the instrument over the threaded stud in top center of the stand (recessed section of instrument front to align with top front of stand), or place on a table or other support, as desired.

d. Plug power cord into socket located at the back of the instrument.

e. Plug the instrument into an appropriate AC outlet.

   NOTES:

   1) Always use the AC power connector, as supplied, to ensure proper grounding.

   2) Charge the batteries for at least 3 to 4 hours before operation on battery power.

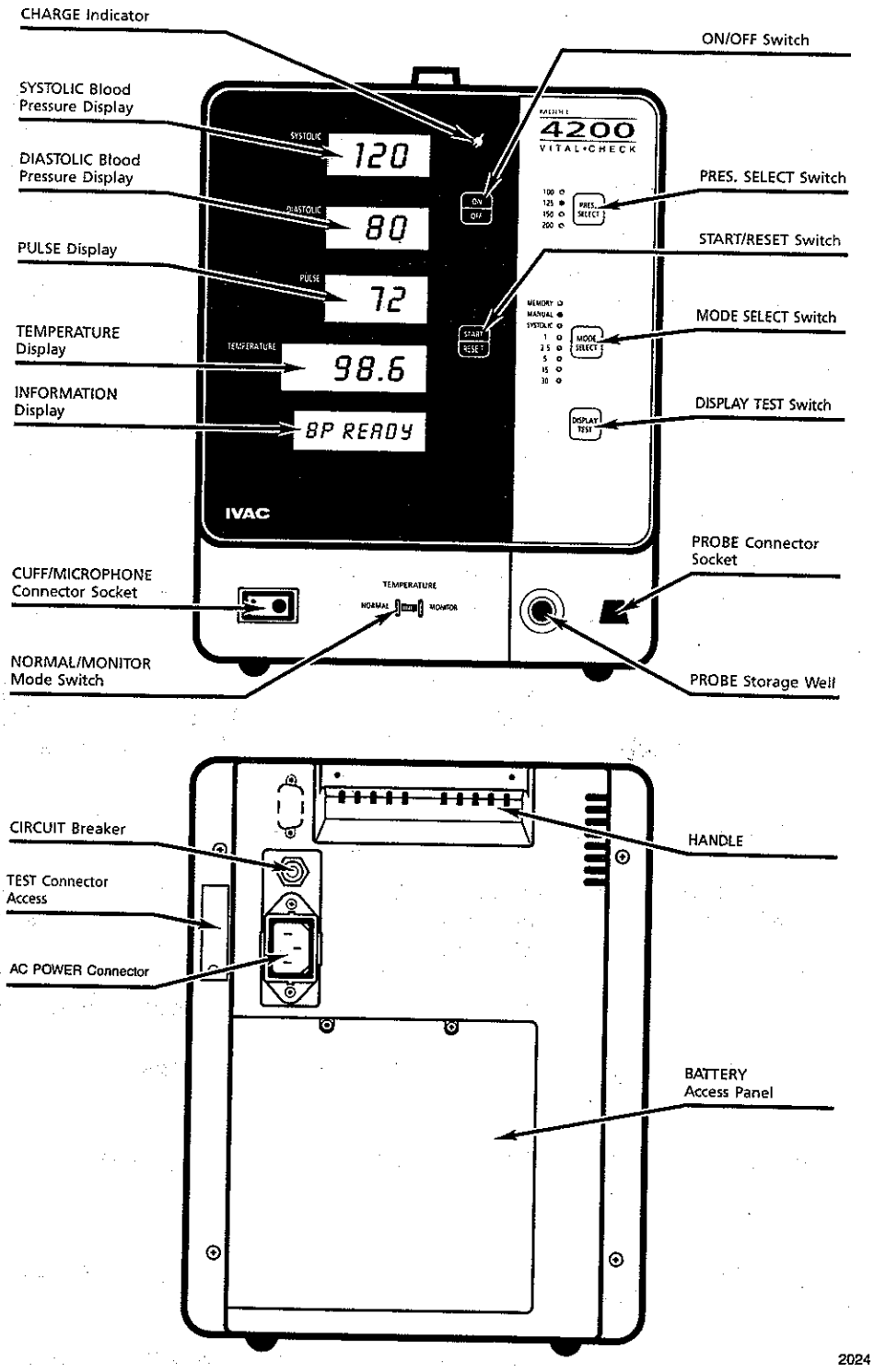


Figure 2-1. Controls and Indicators

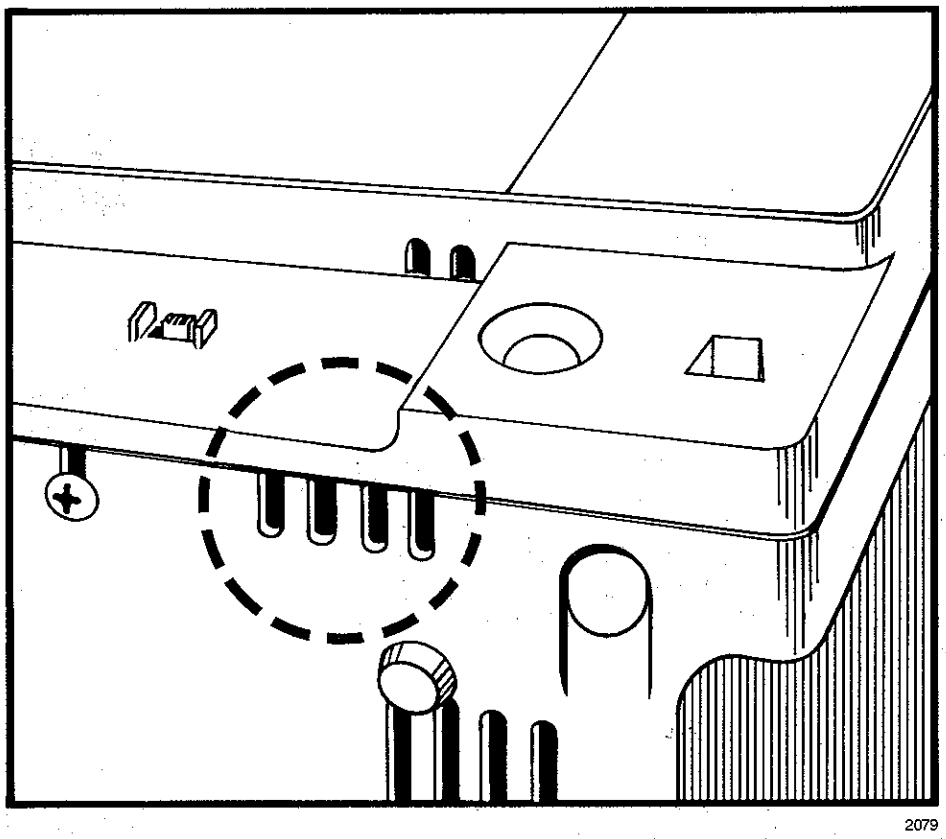
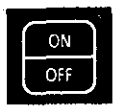
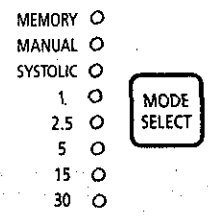
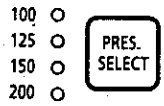


Figure 2-2. Internal DIP Switch (No. 5) Location
(Bottom View of Model 4200)

Table 2-1. Controls/Indicators

Function	Controls/Indicators
ON/OFF switch Applies power to or removes power from the instrument.	
START/RESET switch Initiates measurement cycle or terminates a cycle in progress and returns to the display from stand-by. (Switch can be used to deflate the cuff in the event of patient distress.) Used to step through BP measurements (up to last 20) in MEMORY mode, if power has not been turned off.	
MODE SELECT switch Determines the manual, systolic, automatic, or memory modes. In MANUAL mode, BP measurements are initiated using the START/RESET switch. In SYSTOLIC mode, continuous systolic measurements are performed for about 5 minutes. The automatic mode initiates repetitive measurement cycles at selected intervals of 1, 2.5, 5, 15, or 30 minutes. MEMORY mode allows the user to recall results of previous BP measurements. To access specific mode, press and release switch until desired mode indicator is lit.	

PRES. SELECT switch



Allows for selection of 100, 125, 150, or 200 mmHg initial cuff inflation pressure.

To access specific inflation pressure, press and release switch until desired mode indicator is lit.

Charge indicator

Illuminates when the instrument is plugged into an AC line and the battery is charging.

S2 Internal DIP switch (no. 5) °F/°C

Selects whether the temperature will be displayed in degrees Fahrenheit (°F) or Celsius (°C). Located at the front overhang of the instrument, this unlabeled switch is no. 5 in the row of louver switches (up position = °F, down position = °C). Do not change any other louver switches.

DISPLAY TEST switch

Allows the thermometer to enter the calibration mode and is also used to initiate a display test. In conjunction with the START/RESET switch, this switch is used to enter the off-line display test mode and advance to each test within this mode.

NORMAL/MONITOR Mode switch

Selects normal or monitor mode for temperature measurement.

2.2 OPERATING INSTRUCTIONS

The following section describes instrument operation for testing purposes only. Operating precautions and instructions are included for informational purposes only. For use with patients, refer to the Model 4200 Directions For Use, packed with each instrument.

NOTE: Model 4200C instruments are compatible with the IVAC Computer Interface Module (CIM). For instructions on using the Model 4200C CIM equipped, refer to the CIM II Directions For Use.

All controls and indicators used to operate the instrument are described and illustrated in figure 2-1 and table 2-1. Blood Pressure (BP) display and temperature error messages are described in tables 2-2 and 2-3.

WARNING: Should an instrument be dropped or severely jarred, the instrument should be inspected by a qualified service technician to ensure its proper function.

2.2.1 Blood Pressure/Pulse Operation - MANUAL Mode

In manual mode (MODE SELECT switch set to MANUAL), the instrument initiates a measurement cycle each time the START/RESET switch is pressed and while the instrument is not in standby mode or taking a BP measurement. (Refer to figure 2-1 as necessary.)

a. Ensure that instrument is plugged into an appropriate AC line.

b. Connect the cuff to the umbilical cable by fully inserting the end of the connector into the short length of tubing attached to the cuff.

   The male connector is fully inserted into the tube when the end of the tube bottoms against the connector body at the base of the strain relief.

   CAUTION: To disconnect the cuff from the cuff cord, be sure the microphone is not in its pocket, and hold the connectors--not the wiring--firmly when pulling the connectors apart.

c. Install the microphone by peeling the nylon cover away from the cuff body, which is held against the cuff body with Velcro.*

*Velcro is a registered trademark of VELCRO USA, Inc.

d. Insert the microphone into the small pocket on the inside of the cover.

The Velcro at microphone bag should be attached to the Velcro at pocket, to secure the microphone to the cuff and ensure proper placement of the microphone in the pocket. (See figure 2-3.)

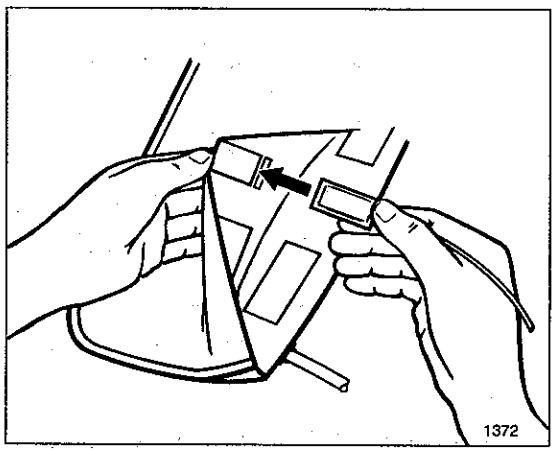


Figure 2-3. Microphone Placement

e. Place excess microphone cord loosely inside the pocket formed between the cover and the cuff body. (See figure 2-3.)

f. Reseal the Velcro to close the cover over excess cord.

g. Plug the BP cuff umbilical cable into the cuff/microphone connector socket on the front of the instrument.

h. Place the cuff microphone directly over the brachial artery (inner arm, above elbow), holding the microphone in place while wrapping the cuff.

NOTE: Wrap the cuff at a slight angle if the patient's arm is excessively tapered. (See figure 2-4.) While wrapping the cuff on the arm, note the index and range marks; if the index mark on the cuff does not fall between the range marks, the wrong size cuff is being used. To ensure accuracy, select a larger or smaller cuff, as required, and repeat steps b through f of this section.

CAUTION: Artery tag must be positioned over brachial artery only. Any other application may result in inaccurate readings.

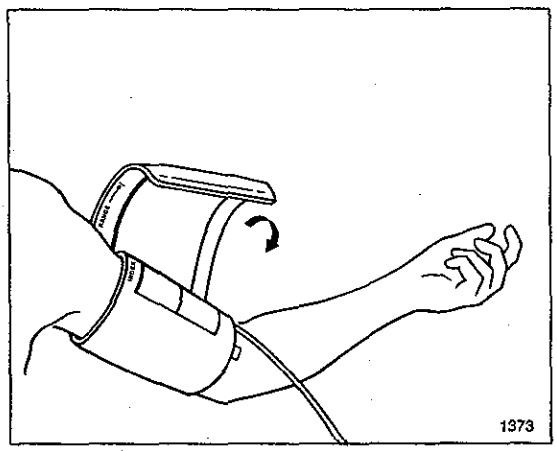


Figure 2-4. Wrapping Cuff

i. Press the ON/OFF switch to turn the instrument on, instruct the patient to relax, remain still, and not to talk during the measurement cycle.

NOTE: The instrument will momentarily read all 8's in the SYSTOLIC, DIASTOLIC and PULSE displays and "TESTING" in the bottommost information display as a display check, then emit two audible beeps.

j. Press and release the PRES. SELECT switch until desired cuff inflation pressure indicator is lit.

k. Press and release the MODE SELECT switch until the MANUAL mode indicator is lit; the MANUAL message will be displayed, indicating manual mode.

l. Initiate a measurement cycle by pressing the START/RESET switch; the instrument will automatically begin a measurement cycle by inflating the cuff to the preselected pressure. (The actual pressure will normally be about 15 mmHg over selected pressure.)

The information display will indicate cuff pressure until the BP is determined. When the BP measurement has been completed, the systolic, diastolic, and pulse, will be displayed; in addition, the BP READY message will display alternately with the mode, and the instrument will sound an audible tone. While each subsequent BP is being determined, the results from the previous measurement will flash on the display.

NOTE: If the microphone is not properly positioned or the Korotkoff sounds are too weak, the BP READY message will be replaced by BP*READY, indicating that the BP was determined by the oscillometric rather than the auscultatory method.

m. Press the ON/OFF switch to turn the instrument off.

2.2.2 Blood Pressure/Pulse Operation - SYSTOLIC Mode

The systolic mode initiates an automatic cycle of continuous systolic measurements for about 5 minutes.

a. For operating in the systolic mode, follow steps a through j of section 2.2.1, press and release the MODE SELECT switch until the SYSTOLIC indicator is lit, then press the START/RESET switch.

During deflation, the cuff pressure will appear on the information display and the systolic measurement will appear on the SYSTOLIC display, then the cuff will quickly deflate to zero. After about 5 seconds, the display will begin flashing and the cuff will begin to reinflate to just above the estimated pressure reading. This sequence is repeated for about 5 minutes, then the information display will read SYSTOLIC COMPLETE, indicating the last systolic measurement.

NOTE: Operation in this mode may result in INFLATION TIME TOO LONG message. If this occurs, turn the instrument off and squeeze cuff to remove remaining air. Turn instrument back on and initiate another set of systolic measurements.

b. To abort at any time during the procedure, press the START/RESET switch once.

c. To restart the procedure, press the START/RESET switch after the cycle has ended.

NOTE: The SYSTOLIC mode will only operate via the auscultatory method. If the instrument is unable to detect Korotkoff sounds during a systolic measurement cycle, the instrument will take one oscillometric BP measurement, including systolic and diastolic BP and pulse, and then discontinue further systolic measurements. The message BP*READY will appear in the information display to indicate that the measurement is oscillometric. If this occurs, reposition the cuff over the brachial artery and press the START/RESET switch to initiate another set of systolic measurements.

2.2.3 Blood Pressure/Pulse Operation - Automatic Mode

(Repetitive Measurements at Selected Intervals)

The automatic mode allows automatic repetitive BP measurements. While using the automatic feature, the instrument will initiate measurement cycles at the interval selected on the MODE SELECT switch.

a. For operating in the automatic mode, follow steps a through j of section 2.2.1, press and release the MODE SELECT switch to the desired time interval (1, 2.5, 5, 15, or 30 minutes).

The selected time will alternate with the BP READY message 5 times when the measurement is complete. After the MODE SELECT switch has been set, the first measurement will start at the selected time interval. The information display will show the time remaining until a measurement will automatically be initiated.

b. If an extra measurement is desired during automatic operation, press the START/RESET switch; this will initiate an extra measurement without changing the time remaining on the previously selected measurement cycle.

c. If at any time you wish to discontinue a BP measurement and deflate the cuff, press the START/RESET switch and cuff pressure will be deflated immediately (all modes).

2.2.4 Irregularity Indicator

Three decimal points flashing in the PULSE display at the completion of a BP measurement indicate a possible irregularity in the pulse; palpate the pulse to evaluate the irregularity.

2.2.5 *Blood Pressure Function Information Display Messages*

Operator prompts/messages may appear during operation of the instrument BP function. (See table 2-2 for messages and corresponding explanations.)

Table 2-2. BP Display Messages

Message Explanation	Display
MANUAL The manual mode is selected.	
SYSTOLIC The systolic mode is selected.	
MEMORY The memory mode is selected.	
1.0 MIN./2.5 MIN./5.0 MIN./30 MIN. The interval (1.0, 2.5, 5.0, 15, or 30), in minutes, selected for automatic mode measurement. xxM xxS Time remaining in minutes and seconds until a measurement will automatically be initiated.	

BP READY

A blood pressure measurement was completed using the auscultatory method; display alternates with the appropriate operating mode message.

BP*READY

A blood pressure measurement was completed using the oscillometric method; display alternates with the appropriate operating mode message.

100/125/150/200

The initial cuff inflation pressure setting (100, 125, 150, or 200 mmHg) during the inflation cycle.

CUFF PRESSURE*

The cuff pressure value during the deflation cycle is displayed along with a blinking asterisk (*), indicating a detected Korotkoff sound.

ARTIFACT

Excessive artifacts have been detected; the display is accompanied by 5 audible tones. The instrument will automatically reinflate and retry the BP measurement.

LOW BATTERY

About 15 minutes of battery life remain before the instrument shuts off.

CHARGE BATTERY

There is not enough charge in the battery to take a BP measurement. The instrument will sound 5 audible tones and then shut off.

LOW SIGNAL

Signal sensed by the instrument is too low for a BP measurement; display is accompanied by 5 audible tones. In both the manual and automatic modes, the instrument will automatically reinflate and retry the BP measurement at half the normal deflation rate.

SYSTOLIC COMPLETE

A systolic cycle (about 5 minutes) has been completed; the display is accompanied by a single, low-frequency tone.

PATIENT MOVEMENT

Excessive patient movement during the measurement process has disturbed the instrument's ability to determine the BP; display is accompanied by 5 audible tones.

CHECK FOR AIR LEAKS

Cuff pressure cannot be controlled accurately because of air leaks; display will be accompanied by 5 audible tones.

LOW CUFF PRESSURE

Inflation pressure was insufficient to occlude artery; instrument will repump (up to a maximum of 2 times) to a higher pressure and initiate another measurement.

NOTE: The pressure will increase by 25 mmHg for the 100, 125, and 150 settings, and by 75 mmHg when set to 200.

INCREASE PRESSURE

The cuff pressure is not high enough to take an accurate measurement after 2 automatic inflation pressure increases; the display is accompanied by 5 audible tones.

CHECK FOR REVERSED MICROPHONE

The microphone installed in the cuff pocket may be reversed. Refer to the Operating Instructions of this manual (section 2.2.1) for proper microphone installation and reinitiate the BP measurement.

CHECK CUFF PLACEMENT

The cuff microphone may not have been placed directly above the brachial artery. Refer to the Operating Instructions of this manual (section 2.2.1) for proper cuff placement.

NOTE: If this message is displayed with all blood pressure readings, a dead microphone channel is the most likely cause, requiring repair of the instrument and/or replacement of the umbilical assembly.

SIGNAL QUALITY

The signal detected by the instrument may be distorted by patient movement or other disturbance. The BP displayed is a best estimate under these conditions.

INFLATION TIME TOO LONG

The system determines that the cuff has been inflated too long without sufficient deflation (vein recovery) time; the display is accompanied by 5 audible tones.

NOTE: The instrument will not initiate a BP measurement while this message is scrolling.

FIX ME x

The instrument detects a malfunction, flashes FIX ME x (x is a letter or number defining the type of malfunction detected), sounds 5 audible tones, and ceases operation. The instrument can only be restarted by pressing the ON/OFF switch. If the malfunction persists after cycling the ON/OFF switch, refer the problem to qualified service personnel.

STANDBY

When operating on battery, all displays are blanked about 19 seconds after they are updated.

2.2.6 MEMORY Mode

The memory mode gives the user the capability to recall (redisplay) the results of the previous 19 BP measurements. Including the one being displayed, the last 20 (or up to 20) BP measurements are stored and can be recalled in a last in first out sequence (the last measurement stored will be the first one recalled).

Two measurements must be taken for the memory mode to operate; if either one or no measurement was taken, the instrument will display NO DATA when memory mode is initiated.

a. To enter the memory mode, press and release the MODE SELECT switch until the MEMORY indicator is lit, then press the START/RESET switch.

b. To redisplay to each preceding measurement, press and release the START/RESET switch once.

NOTE: The contents of the memory will be cleared by turning the instrument power off.

During memory mode operation, the information display tells:

- Which operating mode each measurement was taken in: MANUAL (MAN), SYSTOLIC (SYS), or automatic (1.0, 2.5, 5.0, 15, or 30).
- Whether the reading was obtained by auscultation (no asterisk) or oscillometry (indicated by an asterisk). Example: MAN*4/SYS 8 (auscultation).
- Whether the SIGNAL QUALITY message was displayed (indicated by a "Q").
- Whether the CHECK FOR REVERSED MICROPHONE message was displayed (indicated by an "M").
- Whether the CHECK CUFF PLACEMENT message was displayed (indicated by a "C").

The number of the reading (1 through 19).

NOTE: The word END will appear instead of a number with the last stored measurement. If the instrument was unable to complete a measurement due to an interruption, an abbreviated version of the alarm that occurred will be stored in place of the mode. The abbreviations and the corresponding alarms are:

ART - ARTIFACT
LS - LOW SIGNAL
PM - PATIENT MOVEMENT
AIR - CHECK FOR AIR LEAKS
IP - INCREASE PRESSURE
INF - INFLATION TIME TOO LONG

Alarm (error) messages will be stored during automatic mode operation unless an extra (manually initiated) measurement is taken before the next automatic measurement is initiated. If an extra measurement is taken after an error message and before the next automatically initiated measurement, the manually initiated measurement will replace the previous error message. The information display will read 1.0, 2.5, 5.0, 15 or 30 for a manually initiated measurement that replaces an error message in a series of automatic measurements; otherwise, it will read MANUAL. Alarm messages will not be stored in the systolic or manual modes of operation.

2.2.7 Temperature Measurement - NORMAL Mode

For use with Model 1880L (blue) Oral/1882L (red) Rectal probes only.

Use the NORMAL mode for operation under ordinary clinical conditions since it provides the fastest way of taking a temperature with the instrument.

a. Set the NORMAL/MONITOR Mode switch to the NORMAL mode position.

b. Press the ON/OFF switch to turn the instrument on.

c. Install the desired probe.

   NOTE: Place probe covers in their storage well on the instrument stand.

d. With your thumb and forefinger, grasp the base of the probe and withdraw the probe from its storage well. (This action automatically turns on the thermometer function.)

e. Hold the instrument stand handle with one hand, and with the other hand insert the thermometer probe completely and firmly into a probe cover to ensure a secure fit. (See figure 2-5.)

NOTES:

1) Do not press the button at the base of the probe, as this might loosen or eject the probe cover.

2) IVAC cannot guarantee proper fitting of covers, accuracy of temperature reading, or the overall functions of its thermometer when using probe covers that are not IVAC products.

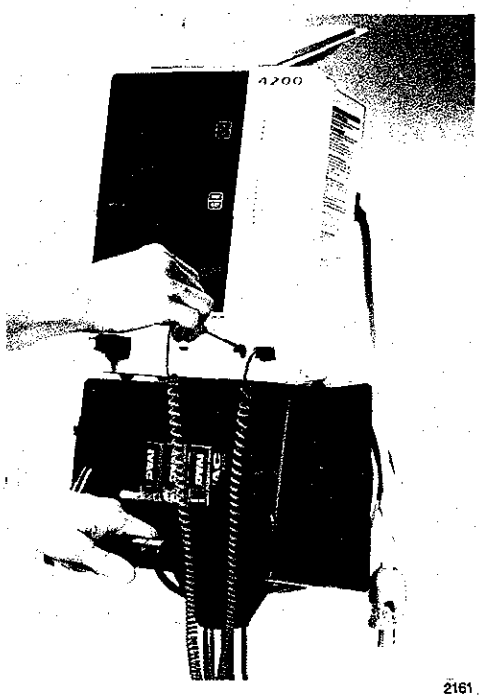


Figure 2-5. Probe Cover Attachment

f. For oral temperatures using the blue 1880L (oral) probe, have patient open mouth slightly, then gently insert the probe tip and slide it back under the front of the tongue, along the gumline, to the sublingual (heat) pocket where the richest blood supply is located. (See figure 2-6.)

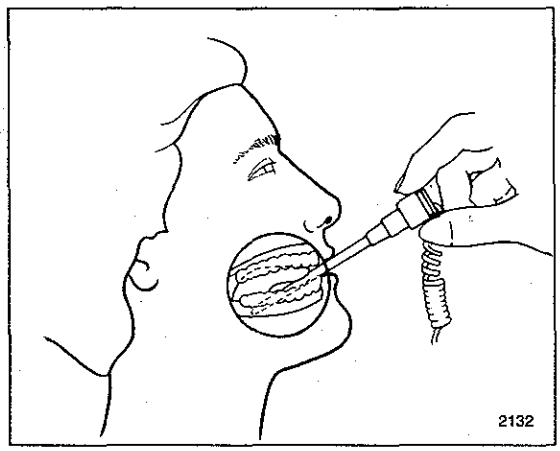


Figure 2-6. Probe Placement

g. Hold the probe during the entire temperature measurement process, keeping the probe tip in contact with tissue at all times; do not allow the patient to reposition the probe.

A tissue contact indicator (pinwheel) will appear in the rightmost position of the TEMPERATURE display during temperature measurement process. When the final temperature is achieved, an audible tone will sound and the patient's temperature (in degrees and tenths of a degree) will blink on the TEMPERATURE display for about 20 seconds. The display will then clear, as the thermometer automatically shuts off.

NOTE: If the probe tip temperature is higher than 94.0°F (34.4°C) as indicated by flashing F or C, the instrument will not quickly determine the patient's temperature. Instead, the temperature indicated on the display will slowly rise until, after 3 to 5 minutes, it stabilizes. No audible tone will sound. This is the same as the MONITOR mode.

h. Note the displayed temperature and remove the probe from the patient's mouth.

i. Hold the probe as you would a syringe, and press the ejection button at the base of the probe to eject the used probe cover into a waste container. (See figure 2-7.)

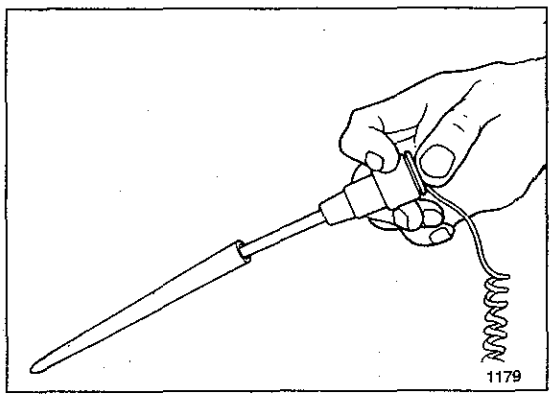


Figure 2-7. Ejecting Probe Cover

j. Return the probe to its storage well, automatically turning off and resetting the thermometer function for the next temperature measurement. (See figure 2-8.)

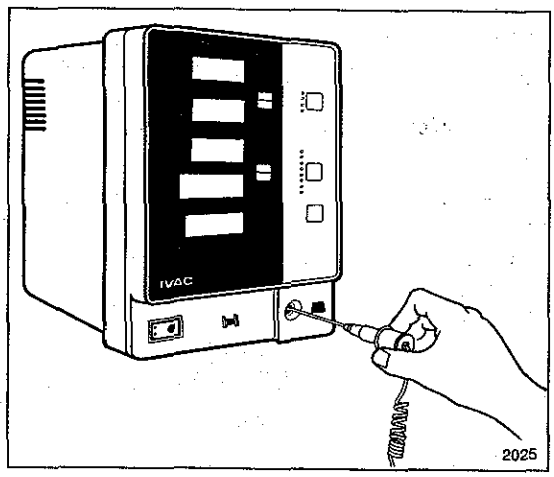


Figure 2-8. Probe Storage Well

k. For rectal temperature measurement, use the red 1882L (rectal) probe; connect the probe to the instrument and attach a probe cover to the probe as described in steps c through e of this section.

l. Touch the tissue about one-half inch above the sphincter muscle and carefully insert the probe, using current hospital technique for penetration. (The use of a lubricant is optional.)

When the final temperature is achieved, an audible tone will sound.

m. Note the temperature, withdraw the probe, and eject the used probe cover as described in steps h and i of this section.

n. Reset the thermometer function as described in step j of this section.

WARNING: Do not push the eject button while the probe is in the patient.

2.2.8 Temperature Measurement - MONITOR Mode

NOTE: In MONITOR mode, the thermometer continuously measures the patient's temperature as it rises or falls.

a. Press the ON/OFF switch to turn the instrument on.

b. Set the NORMAL/MONITOR Mode switch to MONITOR mode position.

c. Select desired probe (1880L or 1882L) and position it according to standard hospital procedure.

Within 3 to 5 minutes the display should stop changing, indicating the patient's current temperature. As the patient's temperature rises or falls, the display will change accordingly; the reading on the display continuously flashes on and off, to indicate operation in the MONITOR mode.

d. When monitoring is no longer desired, remove the probe from the patient, then discard the probe cover into a waste container.

e. Press the ON/OFF switch to turn the instrument off.

2.2.9 Temperature Error Messages

The error messages listed in table 2-3 may appear on the TEMPERATURE display during operation of the temperature function. If an error message occurs while in the normal mode, eject the probe cover, reset the thermometer by returning the probe to its storage well, then retake the patient's temperature.

Table 2-3. Temperature Error Messages

Message Explanation	Display
Err t The instrument fails to obtain a temperature within 1 minute after insertion (in NORMAL mode only).	
Err L The thermometer senses a loss of proper tissue contact within the mouth for more than 30 seconds (in NORMAL mode only).	
Err H The probe temperature exceeds 107.9°F (42.1°C).	
Err 0 There is an analog/digital (A/D) electronics error. If the error persists after resetting the thermometer, return the instrument for service. If an error message occurs while in the NORMAL mode, eject the probe cover, reset the thermometer by returning the probe to its storage well, and retake the patient's temperature.	

2.3 BATTERY OPERATION

This equipment is equipped with a self-contained battery for portable operation.

a. To operate on battery power, unplug the power cord from the AC outlet and continue as you would for AC operation.

   NOTE: To retain full battery charge, keep the instrument plugged into an appropriate AC outlet whenever possible.

   When the battery charge begins to run low while operating on battery power, the instrument will display LOW BATTERY on the information display. This message indicates enough charge for about 15 minutes of operation. As the charge in the battery is further depleted, CHARGE BATTERY will flash, accompanied by 5 audible tones. The instrument will then turn itself off.

   NOTE: When the instrument shuts off, the memory will be erased. Continued attempts to restart the instrument by turning it on again may result in draining the battery completely. If this occurs, the instrument will not respond to any attempt to turn it on until it is plugged into an appropriate AC outlet.

b. Charge the battery for 3 to 4 hours prior to operating on battery power. (To fully charge the battery from a completely discharged state will require 12 to 16 hours.)

   NOTE: Battery information messages are overridden by error messages and operation in MEMORY mode.

   A standby mode exists to conserve battery power. The instrument automatically enters standby mode about 19 seconds after the last display update; STANDBY will flash on the display.

c. To redisplay a measurement result, press the START/RESET switch once.

d. To initiate a BP measurement while the instrument is in standby mode, press the START/RESET switch twice.

2.4 DISPLAY CHECK

a. Press the ON/OFF switch to turn the instrument on, and verify that information display reads TESTING for about 3 seconds and then displays mode setting (i.e., MANUAL, SYSTOLIC, MEMORY).

b. To check the instrument's displays, press and hold the DISPLAY TEST switch.

Eights (8's) will appear in every numeric display position indicating that the displays are operating properly; the information display will alternate between asterisks and "boxes" (capital O's). A probe must be installed on the instrument in order for the temperature display to be tested.

c. The off-line display test mode is used to provide a more complete check of the display characters and to read the instrument's software revision level; to enter this mode, press and hold the DISPLAY TEST switch, then press the START/RESET switch.

d. To exit this mode, either press the DISPLAY TEST switch 3 more times or cycle the ON/OFF switch off, then on again.

2.5 REAL-TIME CLOCK (Model 4200C only)

The Model 4200C has a real-time clock and an interface between the thermometer and main processor to transmit temperature and time of measurement. Operate the instrument in the manual mode as described in the Model 4200 Directions For Use, accompanying each instrument.

2.5.1 To Display Time

a. Press the instrument front panel between the 125 and 150 labels and between the 5 and 15 labels simultaneously for up to 5 seconds, until mode and pressure indicator lights go off.

b. Verify that the current time is displayed in the information display as follows:

in 12-hour format: HH:MM AM (or PM)
in 24-hour format: HH:MM:SS

(where HH = hours, MM = minutes, and SS = seconds).

NOTE: On first power up after disconnecting battery, SET TIME will continue to be displayed until the START/RESET switch is pressed again.

2.5.2 To Set Time and Date

The following instructions are provided to set the instrument calendar and clock to current time.

NOTE: On first power-up after disconnecting battery, SET TIME will be displayed and will override other messages.

a. Perform steps as in section 2.5.1.

b. To change between the 12-hour and 24-hour format, press the START/RESET switch; each press will select the alternate format.

c. To Set Time:

1. Press the DISPLAY TEST switch once:

   In the 12-hour format, AM (or PM) will flash. AM or PM can be selected by pressing the START/RESET switch. Each press will alternate the AM/PM display.

   In the 24-hour format, the seconds display will flash. The seconds may now be set to 01 by pressing the START/RESET switch once.

2. Press the DISPLAY TEST switch once:

   The hours display will now flash. Advance through the hours display by pressing the START/RESET switch once to advance each hour.

3. Press the DISPLAY TEST switch once:

   The minutes 10's display will now flash. Advance through the minutes by tens by pressing the START/RESET switch once to advance each 10 minutes.

4. Press the DISPLAY TEST switch once:

   The minutes 1's display will now flash. Advance through the minutes from 1 to 9 by pressing the START/RESET switch once to advance each minute.

5. Press the DISPLAY TEST switch once:

   The information display will now indicate the date as follows:

   MM - DD - YY

   (where MM = Month, DD = Day, YY = Year).

   The months display will be flashing. Advance through the months by pressing the START/RESET switch once to advance each month.

6. Press the DISPLAY TEST switch once:

   The days display will now flash. Advance through the days of the month by pressing the START/RESET switch once to advance each day.

7. Press the DISPLAY TEST switch once:

   The years tens display will now flash. Advance through the years by ones by pressing the START/RESET switch once to advance each year.

8. Press the DISPLAY TEST switch once:

   The years ones display will now flash. Advance through the years by ones by pressing the START/RESET switch once to advance each year.

9. When the time, date, and year are properly set, press the DISPLAY TEST switch again; the time display will return to the information display.

   NOTE: It is not necessary to go through the complete sequence once this sequence is started. At any point, either the MODE or PRES. SELECT switches can be pressed to exit the setting sequence. Once set, the clock will remain set when the instrument is detached from its power source.

d. Upon exit, be sure to check for correct mode and pressure settings.

2.6 STORING, STERILIZING, AND CLEANING

2.6.1 Storing the IVAC Instrument

When storing the IVAC instrument, connect it to AC power to ensure full battery charge the next time it is used. Do not store the instrument with battery in a discharged state, as this may result in permanent damage.

2.6.2 Sterilizing Instrument

a. The instrument may be EtO gas sterilized, provided that the maximum temperature does not exceed 58°C (136.4°F) and that relative humidity does not exceed 60% noncondensing.

b. After sterilization, aerate the instrument for 24 hours in free air or 8 hours in an aerator.

c. Following aeration, verify proper instrument operation.

2.6.3 Cleaning Instrument

a. Do not steam autoclave or immerse this instrument as damage to the instrument may occur.

b. Periodically clean the exterior surfaces of the instrument and blood pressure cuff, using a cloth dampened with warm water or a mild nonabrasive detergent mixed with water; care should be taken in the choice of cleaning agents and disinfectants (Cidex, Glutarex, and Vestaleen are acceptable) used on this instrument.

c. DO NOT USE ALCOHOL, AMMONIA, OR AMMONIUM CHLORIDE-BASED AGENTS because they may damage the plastic parts and could cause failure of certain critical parts on the instrument.

For general cleaning, use of a mild, nonabrasive detergent mixed in water is recommended. Commercially available liquid dish cleaning detergents work well.

2.6.4 Cleaning Blood Pressure Cuff

a. Disconnect the microphone and umbilical cable.

b. Cover or plug the air inlet fitting on the cuff (umbilical attachment) while cleaning the cuff to prevent water from entering.

c. Clean the cuff by hand using the instrument cleaning method described in section 2.6.3; DO NOT MACHINE LAUNDER THE CUFF AS DAMAGE MAY OCCUR.

2.7 FUNCTIONAL CHECKOUT - REGULAR INSPECTIONS

To ensure the instrument remains in good operating condition, regular inspections are required.

Procedures for inspection may also be provided in future service bulletins. Failure of the instrument to pass any of the tests may necessitate its return to IVAC or an IVAC dealer. Retain all original shipping cartons, packing inserts, and slips.

WARNING: Failure to perform the regular inspections required may result in a failure of the instrument to perform or alarm as specified.

Regular Inspections

Regular inspections consist of performing the procedures described in the Blood Pressure/Pulse Operation (section 2.2.1), Temperature Measurement Operation (section 2.2.2) and Storing, Cleaning, and Sterilizing (section 2.6) sections of this manual before each usage of the instrument.

These inspections are not covered under any contract or agreement offered by IVAC Corporation and must be performed by the user.

CHAPTER THREE - FUNCTIONAL DESCRIPTION

3.0 INTRODUCTION

This chapter contains a functional description of the VITAL•CHECK instrument - Model 4200.

The electrical components are contained on four printed circuit boards and on the front panel and chassis switch panel. (See table 3-1 for monitor boards and abbreviations.)

This instrument has two microprocessors. The main processor is located on the logic/analog board and carries out instructions for blood pressure measurement and global control. A second processor is located on the display/thermometer board, and controls temperature measurement only.

Full schematics for each of the boards are found in Chapter Four, SCHEMATICS, of this manual. (Refer to Chapter Four as applicable.)

Table 3-1. Monitor Boards

Logic/Analog	(LA)
Display/Thermometer	(DT)
Power Regulator	(PR)
Transition	

The main processor is designated U9 and is located on the logic/analog board. The processor on the display/thermometer board is designated U5. In the text, U9 is referred to as the "CPU." U5 is called the "µcontroller."

3.1 OVERVIEW

The VITAL•CHECK instrument is two instruments in one: one measuring system takes temperature, the other measures blood pressure and pulse. They share a common power supply.

The thermometer is an independent system, and contains its own controller and logic. The thermometer cycle is activated by removing the temperature probe from the probe well. When a measurement is completed, the results are reported directly to the temperature display.

The blood pressure and pulse measurement system processes signals from the blood pressure cuff. The measurement cycle begins with cuff inflation. During deflation, the CPU collects and stores data. Three data channels are strobed: microphone audio, pressure oscillations associated with pulse, and cuff pressure readings. At the completion of the cycle the data is processed to detect the pulse (i.e., heart beats). The sound and motion of the pulse is analyzed to identify the characteristic pattern associated with systole and diastole. The absolute pressures in the cuff at systole and diastole are recalled and reported as systolic and diastolic blood pressure.

During operation, the instrument also monitors itself, and will alarm and cease BP and temperature operation if a problem is detected.

The VITAL•CHECK instrument is powered by a rechargeable battery.

There are significant hardware differences between the Model 4200 and CIM equipped Model 4200 instruments. The CIM equipped 4200 contains an external dataport. Supporting circuitry includes a real time clock and I/O port to couple the thermometer display to the CPU bus. These enhancements make the CIM equipped 4200 computer-compatible and permit use of it as part of an automated record keeping system. Circuitry unique to the CIM equipped 4200 is discussed in more detail in section 3.11.

3.2 THE CPU

This section details the CPU, bus structure, clock, clock divider, interrupts and wait state generator.

Block diagrams, figures 3-1 and 3-2, show the control, data and address bus connections between the CPU and peripheral devices. Each peripheral is discussed further in sections 3.3 through 3.10.

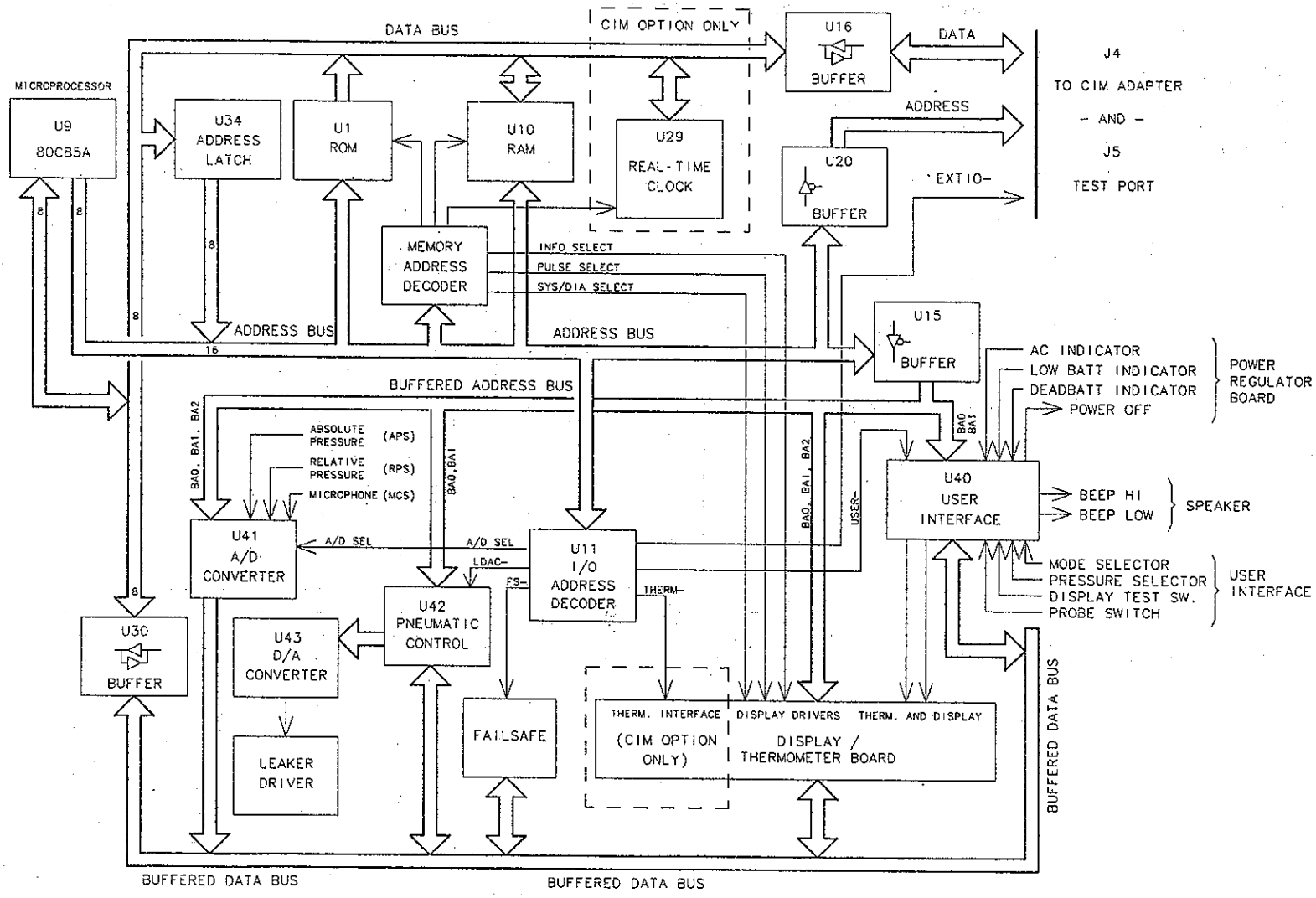


Figure 3-1. Block Diagram of Logic/Analog Board

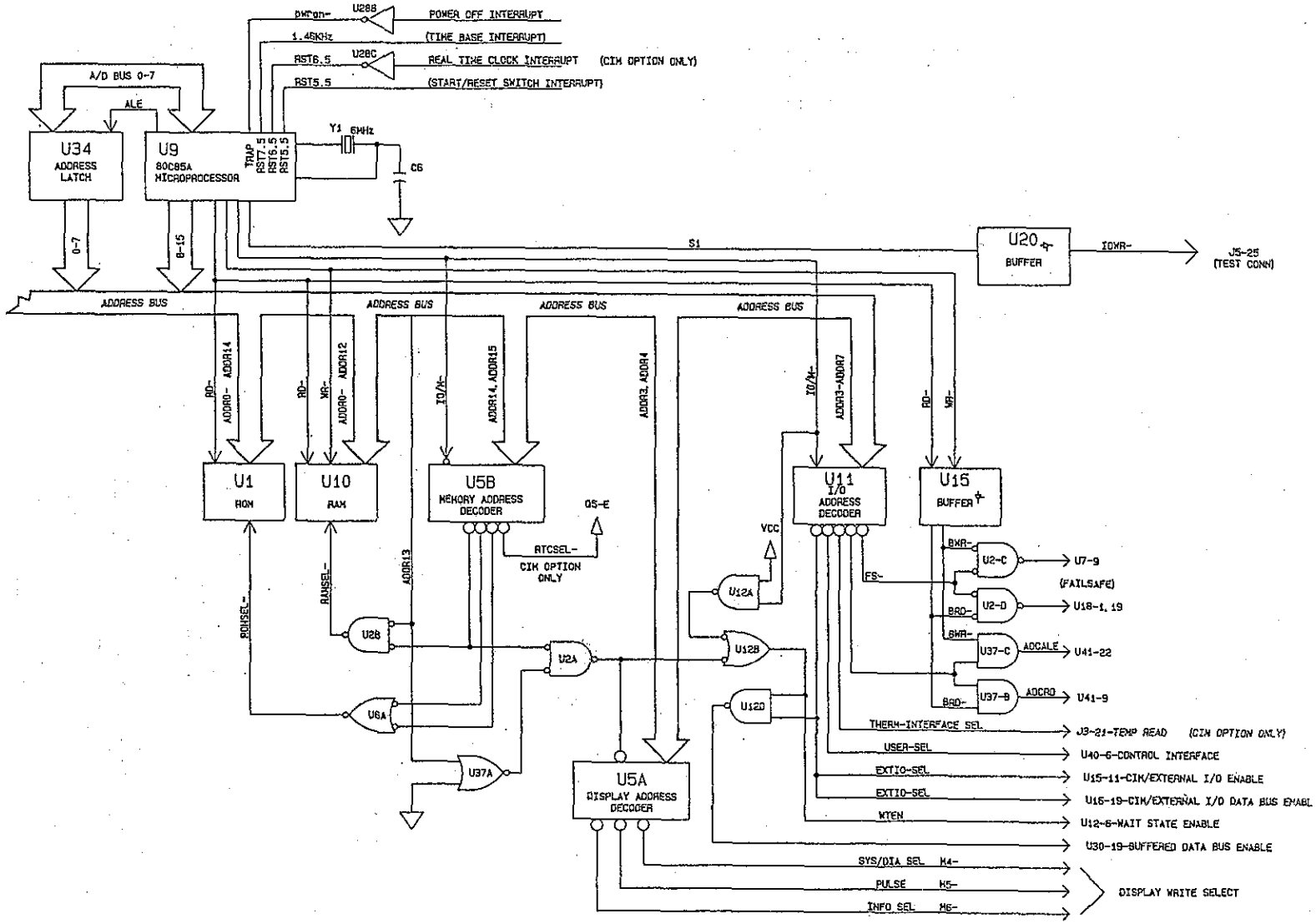


Figure 3-2. Block Diagram of Control and Address Bus Decoding

3.2.1 CPU and Address Latch (figure 3-3)

The CPU, an 80C85 (the CMOS version of the 8085), is an 8-bit microprocessor that features: an integral clock generator; four vectored interrupts; data transfer on a multiplexed, 8-bit, bi-directional, three-state bus (D0-7); 64 kilobyte addressing capability, and addressing of up to 256 I/O locations.

The 80C85 is configured as follows:

a. RSTIN-

Power-up reset is provided by the C13, CR1, and R1 network.

b. RSTOUT

Used to reset U33, U42, and U40.

c. HOLD

Not used.

d. READY

Used as a CPU timing control for wait-state generator.

e. SID (SERIAL INPUT)

Used for developmental purposes only. Monitors one-half of the interrupt clock frequency.

f. SOD (SERIAL OUTPUT)

Buffered by Q1. Used to turn the motor/pump on and off during a blood pressure cuff inflation cycle.

The CPU uses address latch U34 to form the lower 8 bits of the 16-bit address bus. The 16 address bits are used to select a device (RAM, ROM, I/O ports) with which to exchange data.

3.2.2 Data Bus (figure 3-1)

The 8-bit data bus is a conventional three-state bus. Resistor pack RN4 is connected to +5V logic and pulls the data bus lines high during times that the bus may be undriven (3-stated). The buffered bus can be accessed externally through test connector J5 on the logic/analog board.

The data bus connects directly to the address latch (U34), program ROM (U1), RAM (U10), Real-time clock (CIM option only, U29), and two bidirectional buffers (U16 and U30).

One buffer (U16) is for the "CIM/test/external I/O data bus," and is part of the external communications port. It is selected when the CIM/test/external I/O port is selected. It is bidirectional and its normal output to the connector is reversed to drive the CPU data bus during a read cycle.

The second buffer (U30) connects to what will be termed the "buffered data bus." U30 is enabled via gate U12-11. It is bi-directional, and during a read cycle its normal output to the buffered data bus is reversed to drive the CPU data bus.

The schematics refer to the data bus as bits A/D0 through A/D7. On the drawings, the buffered data bus is called bits BDATA0 through BDATA7. The CIM/test/external I/O bus is called out as IOD0 through IOD7.

3.2.3 Buffered Data Bus (figure 3-1)

The buffered data bus is an 8-bit bus, BDATA0 to BDATA7, and is buffered by U30. The buffered data bus connects to all I/O ports and to the display drivers and displays. The block diagram, figure 3-1, shows the relationship between the data bus and the buffered data bus.

Resistor pack RN3 pulls the buffered data bus high when not driven.

3.2.4 CIM/Test/External I/O Buffered Data Bus (figure 3-1)

The external bus is an 8-bit bus, IOD0 to IOD7, for CIM interfacing and testing. Buffer U16 connects to an external I/O port, J4 and J5. Resistor pack RN2 pulls these data bus lines high when not driven.

3.2.5 Address Bus (figure 3-2)

The address bus is a conventional 16-bit system, with the lower 8 bits latched in U34 during the address latch portion of the CPU cycle (ALE goes LO), and the upper 8 bits derived directly from the CPU. Included on the upper 8 bits of the bus are 10kΩ pull-ups to eliminate ambiguous logic levels during times that the bus may be undriven (3-stated).

During an I/O operation the low-order and high-order address bits copy each other.

The address bus is connected directly to the address decoders (U5 and U11), program ROM (U1), RAM (U10), and buffers (U15 and U20). Part of buffer U15 is used to buffer the three lowest-order bits (ADDR0, ADDR1, ADDR2) for all I/O ports and the display drivers and displays. Part of buffer U20 is used to buffer the three lowest-order of the high-order bits (ADDR8, ADDR9, ADDR10) to the test and CIM connectors.

The address bus is not connected to the real-time clock, U29, (CIM option only) as U29 has its own internal address latch, utilizing the ALE signal from the CPU.

The schematics refer to the address bus as ADDRESS BUS, bits ADDR0 through ADDR15. The buffered address bits are BA0, BA1, and BA2. The CIM/test/external I/O connector buffered address bits are IOA0, IOA1, and IOA2.

3.2.6 Control Bus (figure 3-2)

Five signals issued by the CPU are used to control the various devices connected to the CPU. They are:

a. IO/M- (Input/Output or Memory)

HI for an input/output (I/O) operation or LO for a memory read or write operation. IO/M- is used to select the memory address decoder (U5) or the I/O address decoder (U11). A 10kΩ pull-up is included to eliminate ambiguous logic levels during times this line may be undriven (3-stated).

b. RD- (Read)

LO to read a memory location or I/O device. This signal also controls the direction of the bidirectional data bus buffers. RD- is buffered via part of U15 to all I/O ports, and via part of U20 as ERD- to the CIM and test connectors. A 10kΩ pull-up is included to eliminate ambiguous logic levels during times this line may be undriven (3-stated).

c. WR- (Write)

LO to write to a memory location or I/O device. This signal is buffered via part of U15 as BRD- to all I/O ports and displays and display drivers, and via part of U20 as EWR- to the CIM and test connectors. A 10kΩ pull-up is included to eliminate ambiguous logic levels during times this line may be undriven (3-stated).

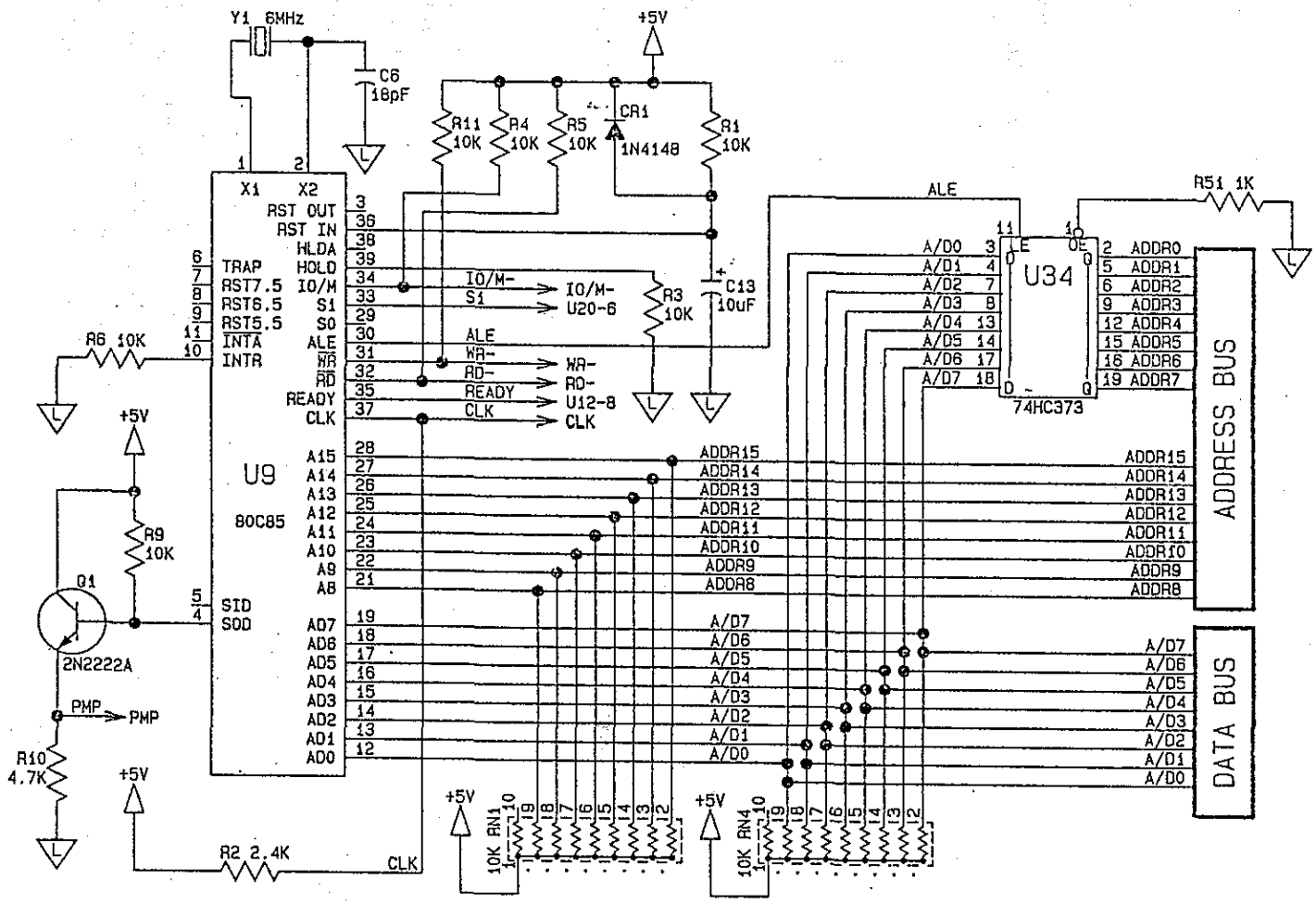


Figure 3-3. CPU and Address Latch

d. S1 (Status 1)

LO during a write operation. This signal is buffered via part of U20 as IOWR- to the CIM and test connectors. This is a special signal used only by the optional CIM module as a read or write signal (RD/WR-).

e. ALE (Address Latch Enable)

HI during first part of processor cycle when the low order address is present on the data bus. The low order address is latched in U34 when ALE goes LO. ALE also connects to the wait-state enable circuit (section 3.2.10) and to the real-time clock (CIM option only).

3.2.7 Clock (figure 3-4)

The entire system timing is derived from the CPU clock, except for the thermometer µcontroller and display scanning. A 6 MHz crystal is used to generate the necessary clock signal for the CPU.

The 6 MHz quartz crystal controls the frequency of an internal oscillator in the CPU. The internal frequency is divided by two to become the CPU clock, with a period of 333 nanoseconds (3 MHz).

The 3 MHz clock signal (CLK) from the CPU is the logic reference frequency.

CLK is buffered via part of U15 as BCLK for the thermometer interface (CIM option only) on the display/thermometer board, and buffered via part of U20 as ECLK for the CIM and test connectors. CLK output is pulled to +5V through R2.

3.2.8 Clock Divider (figure 3-4)

CLK is fed to a 12-bit ripple counter, U26, and divided into harmonically related lower frequencies for other parts of the system. Those frequencies are 375 kHz, 23.4 kHz, 1.46 kHz, and 732 Hz.

a. 375 kHz Signal

This timing signal is used to drive the A/D converter clock (U41) and the failsafe circuit.

b. 23.4 kHz Signal

A 23.4 kHz signal is used to synchronize the switching circuit frequency on the power regulator board.

c. 1.46 kHz Signal

A 1.46 kHz signal from U26 pin 15 is delivered to the RST7.5 interrupt input on the CPU to serve as a time base, and delivered to U36 pin 5 to serve as the high-pitched alarm.

d. 732 Hz Signal

A 732 Hz signal from U26 pin 1 is applied to the SID input on the CPU (for developmental purposes) and to U36 pin 1 as the low-pitched audio alarm. The 732 Hz signal is buffered by Q18, serving as a clock source for the operator control state machines U31 and U32 via U24 clock divider.

3.2.9 Interrupts (figure 3-2)

The 80C85 CPU interrupt system is configured as follows:

a. RST7.5 (pin 7)

The time base interrupt RST7.5 is the basis of all the software timing in the instrument. Some functions of the time base interrupt are controlling the deflation rate, determining pulse rate and operating the auto mode timers. U26, a binary divider chain, is driven from the 3 MHz CPU clock. The eleventh stage provides a 1.46 kHz (683 microsecond) signal to RST7.5 so that every 683 microseconds the CPU is interrupted to update timers and perform other periodic tasks. This interrupt is always in effect when the instrument is turned on, except for the initial start-up sequence.

b. RST6.5 (pin 8)

Interrupt RST6.5 is generated by the real-time clock (U29, CIM option only). Once per second, upon completion of updating its registers, the real-time clock issues an interrupt via U28-6 to the CPU. When the real-time clock is ready to be read, it pulls its pin 19 LO, driving U28 pin 6 HI, to interrupt the CPU.

In Model 4200A instruments, U29 is not installed and U28 pin 6 is always HI via R16, so RST6.5 is always LO, resulting in no interrupt.

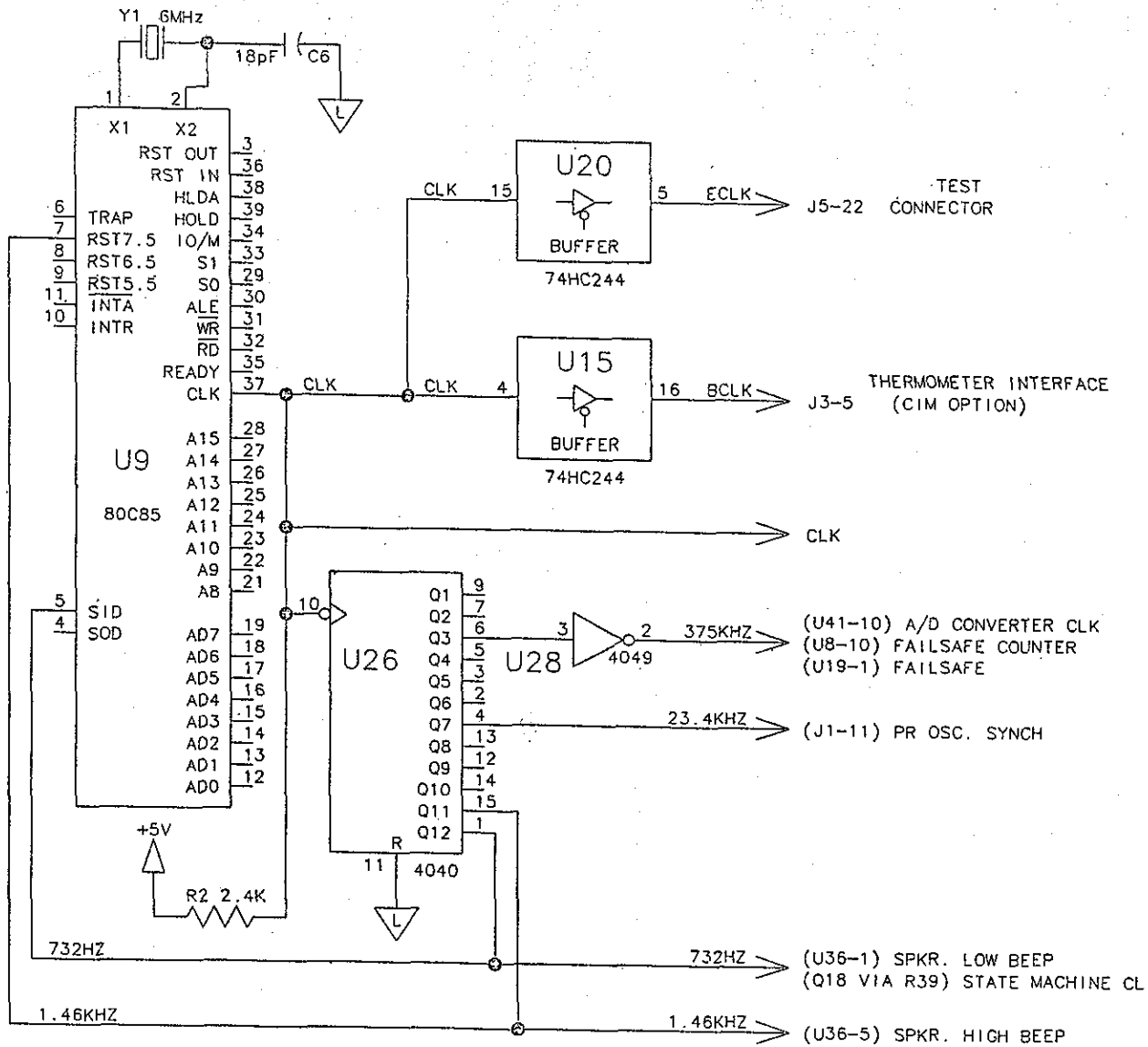


Figure 3-4. Clock and Clock Divider

c. RST5.5 (pin 9)

The instrument's START/RESET function is through the low priority interrupt, RST5.5 (figure 3-5). This interrupt is provided by U32, which is used to debounce the START/RESET switch. Pressing the START/RESET switch brings U32 pin 3 LO (STARTSW-) which results in a synchronized and debounced HI signal at U32 pin 16 (START). This generates an RST5.5 interrupt at the CPU. Releasing the START/RESET switch allows U32 pin 3 to go HI, bringing U32 pin 16 LO.

d. TRAP (pin 6)

The power-down interrupt TRAP is used to allow the CPU to shut down before power is actually removed. When the instrument is turned off, U28 pin 5 goes LO, causing pin 4 to go HI. This causes the CPU to execute a TRAP interrupt (highest priority) and stop before the +5V logic supply is removed. This feature is principally incorporated for the CIM equipped instruments to avoid disrupting the real-time clock, but is functional in all the instruments.

3.2.10 Wait-State Generator (figure 3-6)

U21 and U12-8 comprise a circuit which adds one extra clock period (i.e., a "wait state" of 333 nanoseconds), to the access cycles of the displays and I/O ports to accommodate the extra propagation delay of the bus buffers and slower access devices such as the A/D converter. The wait state is activated each time either of the bidirectional buffers U16 and U30 are enabled.

A wait state request is presented to the CPU READY input for I/O or display address. WTEN enables gate U12-8 during IO/M- or display select, applying the timing signal from U21 pin 9 to the CPU READY.

At each processor cycle, the arrival of the high leading edge of ALE at U21 pin 3 causes a HI signal to be clocked through to U21-9 and out to U12 pin 10, where it is ANDed with WTEN to hold the CPU in a wait state.

When the high is clocked into U21-9, U21-5 is cleared until the next CPU ALE cycle, which also causes U21-9 to be clocked LO, allowing the CPU to exit the wait state.

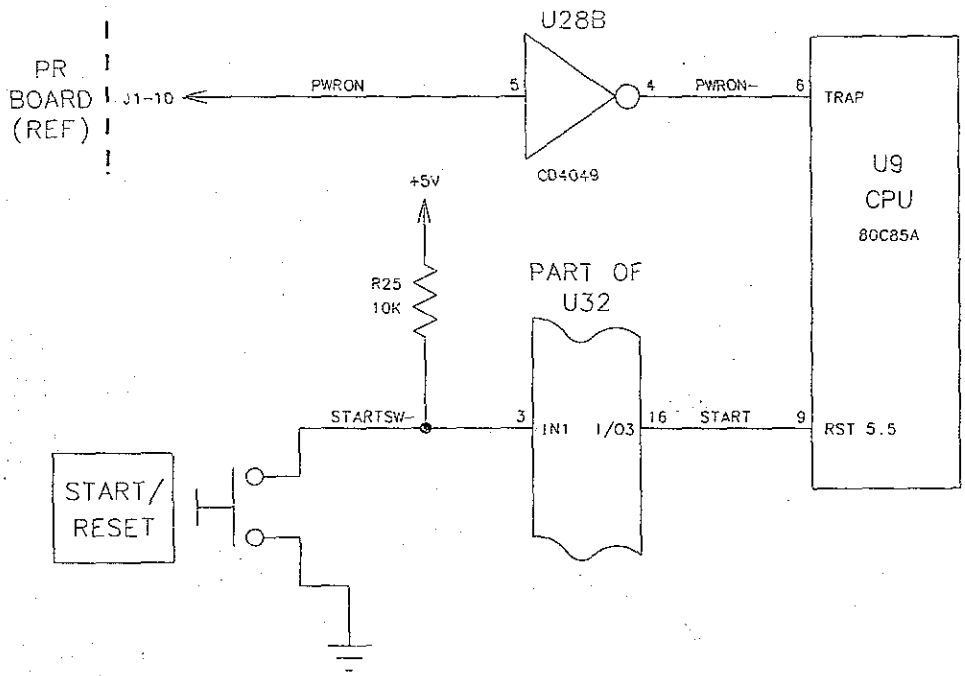


Figure 3-5. START/RESET Interrupt

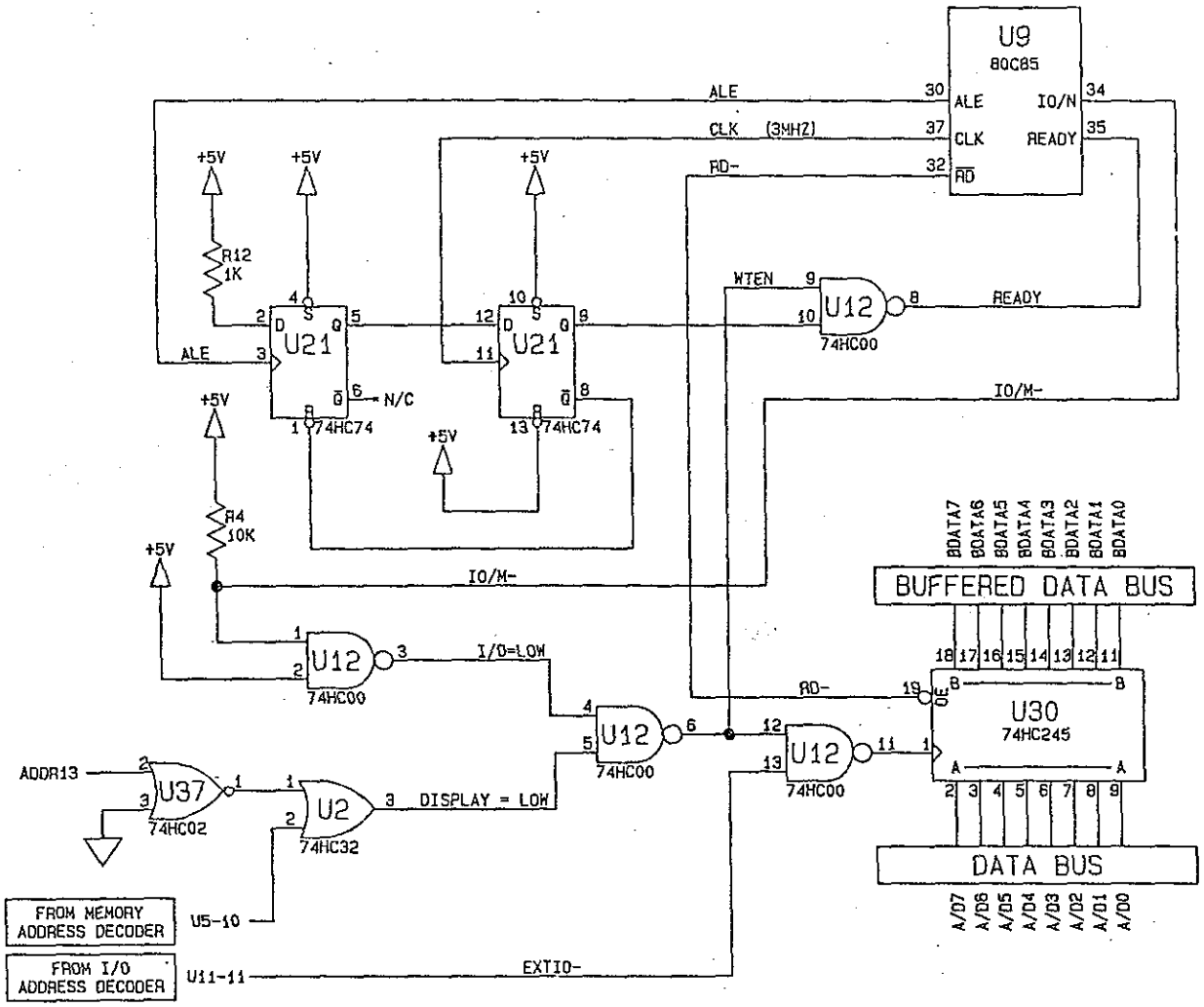


Figure 3-6. WTEN and READY Signals (U410)

3.3 MEMORY ADDRESS AND DISPLAY DECODING (figure 3-7)

The memory address decoder comprises two sections of U5. These are a dual two-to-four decoder with accompanying logic gates.

Decoder U5 is used in conjunction with gates U6-3, U2-6, U2-3, and U37-1 to enable memory-mapped parts of the system. This includes the displays, RAM, ROM, and in the CIM equipped instrument, the real-time clock. Table 3-2 shows the decoder configuration.

Displays are memory-mapped (figure 3-7). The displays consist of two alphanumeric DL2416s (giving eight-character message capacity) and separate 3-digit LED displays for systolic blood pressure, diastolic blood pressure, and pulse.

Address decoder U5-15 is enabled when IO/M- is LO. At that time, ADDR14 and ADDR15 will cause one of the four outputs Y0, Y1, Y2, or Y3 to go LO. Y0 or Y1 select ROM. Y2 selects RAM via U2-6, if ADDR13 is LO; or selects the displays if ADDR13 is HI, via U37-1 and U2-3. Pin 3 of U2 is LO when the displays are selected. This enables U5-1 where further decoding for the displays is done. This signal also enables the CPU wait state and enables the buffered data bus buffer via U12-6 (WTEN).

It should be noted that temperature is displayed in a fourth LED cluster under the control of a separate microprocessor on the temperature board. Refer to section 3.10.

3.3.1 Read Only Memory (ROM, U1, figure 3-8)

The blood pressure measurement program is stored in one EPROM (total program space is 32K x 8).

The software program is outlined in section 3.12.2.

3.3.2 Random Access Memory (RAM, U10, figure 3-9)

The RAM is an 8KB x 8 or 32KB x 8 static device used as data storage and CPU stack. It is selected via U5B and U2B (RAMSEL-) and controlled by RD- for read and WR- for write operations.

The instrument is designed to accomodate either an 8 KB x 8 or a 32 KB x 8 device without changing switches or jumpers. This is accomplished by pin 26 being tied HI (CS2 on 8 KB x 8, A13 on 32 KB x 8) and by pin 1 being tied LO (no connection on 8 KB x 8, A14 on 32 KB x 8). The 32 KB x 8 device functions as an 8 KB x 8 device in this application.

3.3.3 Display Drivers

The blood pressure, pulse, and information displays are memory-mapped.

Display drivers U1 and U4 on the display/thermometer board are connected to the buffered data bus BDATA0 through BDATA4, and are enabled by M4- and M5- from the memory address decoder (U5). U1 is the systolic and diastolic display driver. U4 is the pulse display driver.

The information displays DS15 and DS16 are selected by M6-. These 64 character displays perform additional decoding of BA0-2 and are also connected to the buffered data bus.

Memory display decoding is tabulated in table 3-2. Functional descriptions of the 7-segment and information displays are provided in section 3.7.

3.3.4 Real-Time Clock (U29, CIM option only)

The real-time clock is initialized by write commands from the CPU and is read when date and time is required for the 4200 measurment system.

After updating its registers once a second, the real-time clock issues an interrupt (RST6.5) to the CPU to indicate that it is safe to read the registers.

U29 is enabled by Q5, driven by RTCSEL- from the memory address decoder. To prevent disruption to U29 registers during power down, the chip enable (CS) is held high by circuitry explained in section 3.11.3.

Table 3-2. Memory/Display Address Decoding

MEMORY	IO/M-	RD-	WR-	S1	ADDR 0	ADDR 1	ADDR 2	ADDR 3	ADDR 4	ADDR 5	ADDR 6	ADDR 7	ADDR 8	ADDR 9	ADDR 10	ADDR 11	ADDR 12	ADDR 13	ADDR 14	ADDR 15
MEMORY ADDRESS DECODER: U5B																				
READ ONLY MEMORY (Y0, Y1) U1																				
READ (ROMSEL- = LO)	0	0	1	X	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	0
RANDOM ACCESS MEMORY (Y2) U10																				
READ (RAMSEL- = LO)	0	0	1	X	A	A	A	A	A	A	A	A	A	A	A	A	A	0	0	1
WRITE (RAMSEL- = LO)	0	1	0	X	A	A	A	A	A	A	A	A	A	A	A	A	A	0	0	1
REAL-TIME CLOCK (Y3) U29																				
READ (RTCSEL- = LO)	0	0	1	X	A	A	A	A	A	A	X	X	X	X	X	X	X	X	1	1
WRITE (RTCSEL- = LO)	0	1	0	X	A	A	A	A	A	A	X	X	X	X	X	X	X	X	1	1

NOTE: Symbols (X) not used; (A) indicates an address selection within the address range of the device.

Table 3-2. Memory/Display Address Decoding (cont.)

MEMORY	IO/M-	RD-	WR-	S1	ADDR 0	ADDR 1	ADDR 2	ADDR 3	ADDR 4	ADDR 5	ADDR 6	ADDR 7	ADDR 8	ADDR 9	ADDR 10	ADDR 11	ADDR 12	ADDR 13	ADDR 14	ADDR 15
DISPLAY ADDRESS DECODER: U403B																				
Systolic LSD (1s unit)	0	1	0	X	0	0	0	0	0	X	X	X	X	X	X	X	X	1	0	1
Systolic NSD (10s unit)	0	1	0	X	1	0	0	0	0	X	X	X	X	X	X	X	X	1	0	1
Systolic MSD (100s unit)	0	1	0	X	0	1	0	0	0	X	X	X	X	X	X	X	X	1	0	1
Diastolic LSD (1s unit)	0	1	0	X	0	0	1	0	0	X	X	X	X	X	X	X	X	1	0	1
Diastolic NSD (10s unit)	0	1	0	X	0	0	0	1	0	X	X	X	X	X	X	X	X	1	0	1
Diastolic MSD (100s unit)	0	1	0	X	0	0	0	0	1	X	X	X	X	X	X	X	X	1	0	1
Pulse LSD (1s unit)	0	1	0	X	1	1	0	1	0	X	X	X	X	X	X	X	X	1	0	1
Pulse NSD (10s unit)	0	1	0	X	0	0	1	1	0	X	X	X	X	X	X	X	X	1	0	1
Pulse MSD (100s unit)	0	1	0	X	1	0	1	1	0	X	X	X	X	X	X	X	X	1	0	1
Information left	0	1	0	X	1	1	1	0	1	X	X	X	X	X	X	X	X	1	0	1
Information 2	0	1	0	X	0	1	1	0	1	X	X	X	X	X	X	X	X	1	0	1
Information 3	0	1	0	X	1	0	1	0	1	X	X	X	X	X	X	X	X	1	0	1
Information 4	0	1	0	X	0	0	1	0	1	X	X	X	X	X	X	X	X	1	0	1
Information 5	0	1	0	X	1	1	0	0	1	X	X	X	X	X	X	X	X	1	0	1
Information 6	0	1	0	X	0	1	0	0	1	X	X	X	X	X	X	X	X	1	0	1
Information 7	0	1	0	X	1	0	0	0	1	X	X	X	X	X	X	X	X	1	0	1
Information right	0	1	0	X	0	0	0	0	1	X	X	X	X	X	X	X	X	1	0	1

NOTE: Symbols (X) not used; (A) indicates an address selection within the address range of the device.

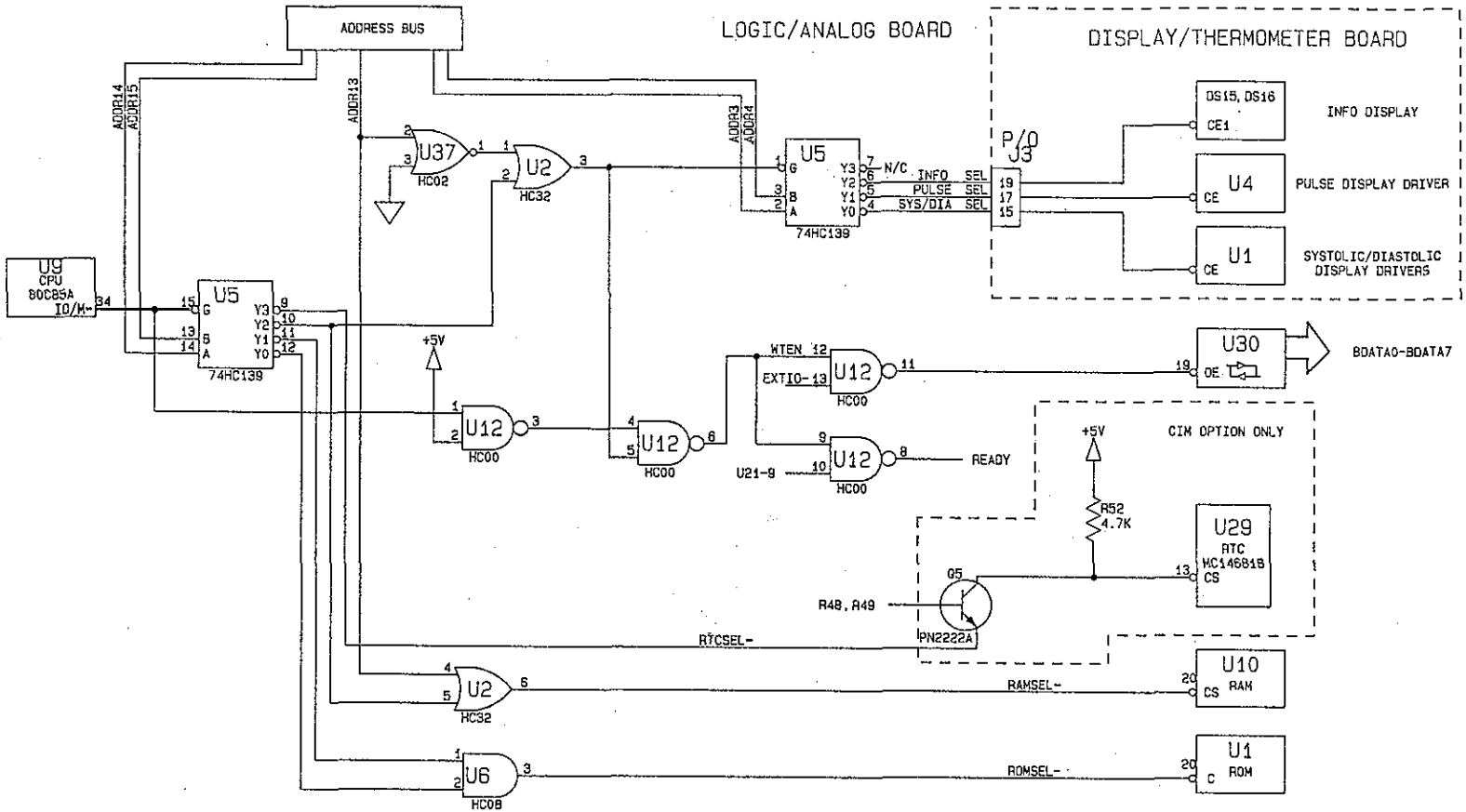


Figure 3-7. Memory Address Decoder and Display Drivers

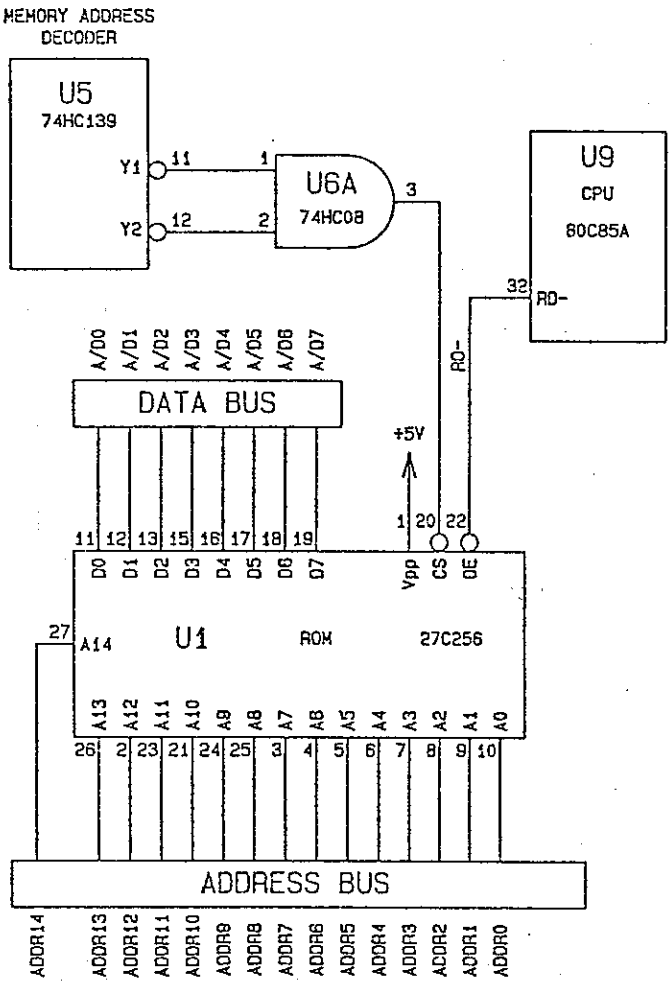


Figure 3-8. Read Only Memory

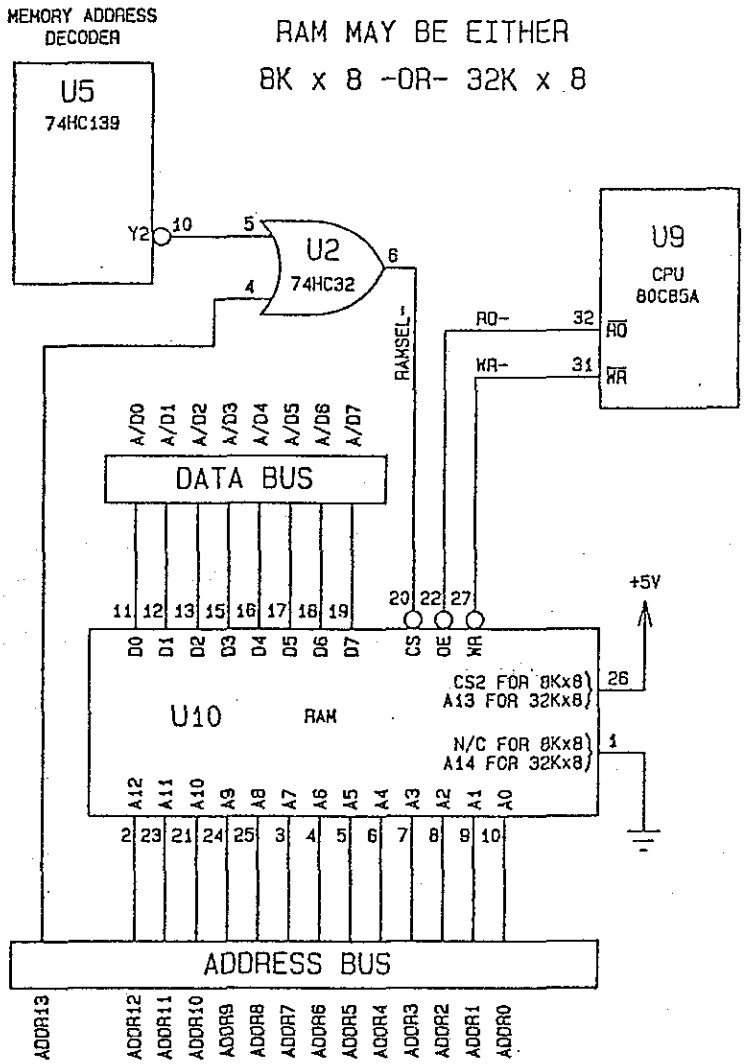


Figure 3-9. Random Access Memory

3.4 I/O ADDRESS DECODING (U11, figure 3-10)

Address decoder U11 is used to enable all the I/O ports. I/O devices include:

- A/D converter port
- Pneumatic control port and D/A latch
- User interface port
- TEMPERATURE display interface port (CIM option only)
- Failsafe I/O port
- CIM interface and test connector

Address decoder U11 is enabled when IO/M- is HI and bits ADDR6 and ADDR7 are LO. At that time, ADDR3, ADDR4, and ADDR5 will cause one of the six outputs, Y0 through Y5, to go LO. Y0 is gated with BWR- in U37-10 to form an A/D address load strobe and with BRD-in U37-4 to form an A/D buffer read strobe. Y1 selects the D/A latch and analog control I/O port. Y2 selects the operator controls I/O port. Y3 selects the failsafe I/O port and Y4 selects the test connector and CIM. Y4 also enables U16, the bidirectional data bus buffer and disables U30, the internal buffered data bus buffer via U12-11. On the CIM equipped instruments, Y5 selects the thermometer interface I/O port. Table 3-3 summarizes the I/O decoder configuration.

3.4.1 A/D Converter Port (U41, figure 3-10)

The A/D converter, U41 on the logic/analog board, is an 8-bit successive approximation type with a built-in, 8-channel multiplexer.

U41 is controlled by ADCRD, ADCALE and a HI at ST. Two pressure and one audio data conversion channels are selected by further internal decoding of BA0 - BA2.

The functional description of the A/D converter is part of blood pressure data acquisition and is supplied in section 3.5.4.

3.4.2 Pneumatic Control Port (U42, figure 3-10)

The pneumatic control is U42 on the logic/analog board. This is a 3-port device. The first two ports (PA4-7 and PB0-7) are used as the 12-bit data latch for the D/A converter. PA0-3 are unused. The third port is divided into two 4-bit sections. PC4-7 is used to read the first 4 positions of the S2 switch on logic/analog board

(S2 switches 5 and 6 are read/used differently). PC0-3 are outputs. PC0 controls the dump valve (DFO-). PC1 is used to hold the leaker closed (LSO). PC2 is used to hold the leaker open (LFO-). PC3 is the A/D converter conversion control.

3.4.3 User Interface Port (U40, figure 3-10)

The user interface I/O port, U40 on the logic/analog board, is one of two 8255A IC's in the instrument. Ports PA, PB and PC are used.

The first port (PA0-7) and part of the second port (PB0) are used to read the MODE selector setting. The rest of the second port is used to read the pressure selector setting (PB1, PB2), the thermometer probe switch (PB3), the display test switch (PB4), the battery status from the power regulator (PB5, PB6), and the AC power status from the power regulator (PB7).

The third port is used as an output port as follows: select high pitch beep (PC0), select low pitch beep (PC1), thermometer display test (PC4), turn on thermometer (PC5), and turn instrument off (PC7). The remaining three bits are not used.

Further description is found in section 3.6.

3.4.4 Temperature Display Interface Port (U10 - Display/Thermometer Board, CIM Option Only, figure 3-10)

The temperature display interface, U10 on the display/thermometer board, is a programmed peripheral with 1 kilobyte of program ROM and 64 bytes of RAM. It is enabled by THERM- from the I/O address decoder.

To the CPU, U10 is an I/O port. However, it is a satellite processor that reads and converts the COP444L temperature display driver output to 80C85 compatible data that is read by the CPU.

Further description is found in section 3.12.

Table 3-3. I/O Decoding

I/O PORT	IO/M-	RD-	WR-	S1	ADDR 0	ADDR 1	ADDR 2	ADDR 3	ADDR 4	ADDR 5	ADDR 6	ADDR 7	ADDR 8	ADDR 9	ADDR 10	ADDR 11	ADDR 12	ADDR 13	ADDR 14	ADDR 15
I/O ADDRESS DECODER: U11																				
A/D CONVERTER (Y0) U41																				
A/D address load (ARCALE = HI, BWR- = LO)																				
Select microphone (MSC)	1	1	0	X	0	0	0	0	0	0	0	0	X	X	X	X	X	X	X	X
Select relative pressure (RPS)	1	1	0	X	1	0	0	0	0	0	0	0	X	X	X	X	X	X	X	X
Select absolute pressure (APS)	1	1	0	X	0	1	0	0	0	0	0	0	X	X	X	X	X	X	X	X
A/D buffer read (ADCRD = HI, BRD- = LO)	1	0	1	X	X	X	X	0	0	0	0	0	X	X	X	X	X	X	X	X
A/D start conversion	1	1	0	X	0	1	X	1	0	0	0	0	X	X	X	X	X	X	X	X
PNEUMATIC CONTROL (Y1) U42																				
PC0, dump valve open command (DFO-)	1	1	0	X	0	1	X	1	0	0	0	0	X	X	X	X	X	X	X	X
PC1, hold leaker closed command (LSO)	1	1	0	X	0	1	X	1	0	0	0	0	X	X	X	X	X	X	X	X
PC2, hold leaker open command (LFO-)	1	1	0	X	0	1	X	1	0	0	0	0	X	X	X	X	X	X	X	X
PC3, A/D start conversion	1	1	0	X	0	1	X	1	0	0	0	0	X	X	X	X	X	X	X	X
PC4-7, Test/Cal Config., S2 DIP switch	1	0	1	X	0	1	X	1	0	0	0	0	X	X	X	X	X	X	X	X
D/A LATCH (Y1) U42																				
PA4-7	1	1	0	X	0	0	X	1	0	0	0	0	X	X	X	X	X	X	X	X
PB0-7	1	1	0	X	1	0	X	1	0	0	0	0	X	X	X	X	X	X	X	X

NOTES: (1) During I/O operation, A8-A15 copy A0-A7.
(2) Symbols (X) not used; (A) indicates an address selection within the address range of the device.

Table 3-3. I/O Decoding (cont.)

I/O PORT	IO/M-	RD-	WR-	S1	ADDR 0	ADDR 1	ADDR 2	ADDR 3	ADDR 4	ADDR 5	ADDR 6	ADDR 7	ADDR 8	ADDR 9	ADDR 10	ADDR 11	ADDR 12	ADDR 13	ADDR 14	ADDR 15
USER INTERFACE PORT (Y2) U40																				
PA0-7, PB0, read MODE switch setting	1	0	1	X	0	0	X	0	1	0	0	0	X	X	X	X	X	X	X	X
PB1-2, read pressure switch setting	1	0	1	X	1	0	X	0	1	0	0	0	X	X	X	X	X	X	X	X
PB3, read thermometer probe sensor	1	0	1	X	1	0	X	0	1	0	0	0	X	X	X	X	X	X	X	X
PB4, read display/test switch	1	0	1	X	1	0	X	0	1	0	0	0	X	X	X	X	X	X	X	X
PB5-6, read battery status from PR board	1	0	1	X	1	0	X	0	1	0	0	0	X	X	X	X	X	X	X	X
PB7, read AC power status	1	0	1	X	1	0	X	0	1	0	0	0	X	X	X	X	X	X	X	X
PC0, select LO BEEP speaker drive	1	1	0	X	0	1	X	0	1	0	0	0	X	X	X	X	X	X	X	X
PC1, select HI BEEP speaker drive	1	1	0	X	0	1	X	0	1	0	0	0	X	X	X	X	X	X	X	X
PC2, not used																				
PC3, not used																				
PC4, run display test	1	1	0	X	0	1	X	0	1	0	0	0	X	X	X	X	X	X	X	X
PC5, activate themometer function	1	1	0	X	0	1	X	0	1	0	0	0	X	X	X	X	X	X	X	X
PC6, not used																				
PC7, turn instrument off	1	1	0	X	0	1	X	0	1	0	0	0	X	X	X	X	X	X	X	X
FAILSAFE INPUT PORT (Y3)																				
U18, FS- = LO, BRD- = LO	1	0	1	X	X	X	X	1	1	0	0	0	X	X	X	X	X	X	X	X
FAILSAFE OUTPUT PORT (Y3)																				
U7, FS- = LO, BWR- = LO	1	1	0	X	X	X	X	1	1	0	0	0	X	X	X	X	X	X	X	X

NOTES: (1) During I/O operation, A8-A15 copy A0-A7.
(2) Symbols (X) not used; (A) indicates an address selection within the address range of the device.

Table 3-3. I/O Decoding (cont.)

I/O PORT	IO/M-	RD-	WR-	S1	ADDR 0	ADDR 1	ADDR 2	ADDR 3	ADDR 4	ADDR 5	ADDR 6	ADDR 7	ADDR 8	ADDR 9	ADDR 10	ADDR 11	ADDR 12	ADDR 13	ADDR 14	ADDR 15
CIM/TEST CONNECTORS (Y4) U16																				
READ	1	0	1	1	X	X	X	0	0	1	0	0	A	A	A	X	X	X	X	X
WRITE	1	1	0	0	X	X	X	0	0	1	0	0	A	A	A	X	X	X	X	X
THERMOMETER DISPLAY INTERFACE (Y5) U10																				
Read status	1	0	1	X	1	X	X	1	1	0	1	0	0	X	X	X	X	X	X	X
Read data	1	0	1	X	0	X	X	1	1	0	1	0	0	X	X	X	X	X	X	X
Write test command	1	1	0	X	0	X	X	1	1	0	1	0	0	X	X	X	X	X	X	X

NOTES: (1) During I/O operation, bits A8-15 copy A0-A7.
(2) A8, A9, an A10 determine the address level within the CIM/test/external I/O port.
(3) For CIM, A8 is IOA0 and A9 is IOA1.
(4) A10 does not affect CIM addressing, but is IOA2.
(5) Symbols (X) not used; (A) indicates an address selection within the address range of the device.

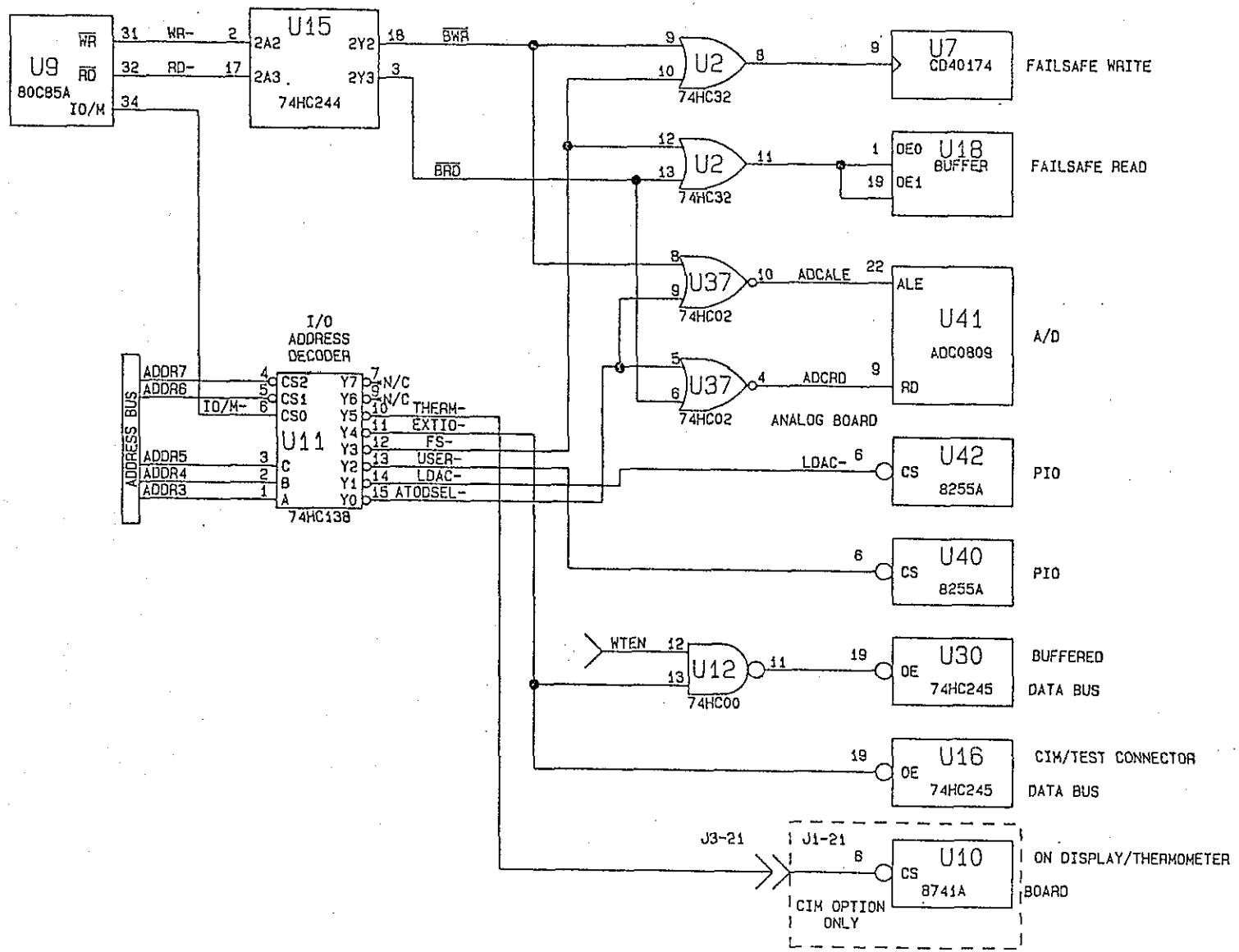


Figure 3-10. I/O Address Decoding

3.4.5 Failsafe Ports (U18, U7 figure 3-10)

The failsafe input port is a 3-state buffer, U18, which is enabled by ANDing the failsafe select (FS-) from the I/O address decoder and buffered read (BRD-) in U2D. Performing a read operation places the current failsafe status on the buffered data bus. The failsafe output port is a six-bit latch, U7, which latches the lower six bits of the buffered data bus (BDATA0 through BDATA5). It is clocked by the trailing edge of buffered write (BWR-) ANDed with failsafe select (FS-) during a write operation in U2-8. The contents of U7 remain latched until another write operation, or cleared via pin 1.

3.4.6 CIM/Test Connectors (figure 3-10)

The signals at this connector are buffered with their own buffers, U16 and U20. U16 is a bidirectional buffer for the data bus and U20 buffers the rest of the related I/O signals, ERD- (read), EWR- (write), IOWR- (CIM read or write) and ERESET (CPU power-on reset). Eight address levels are available via IOA0, IOA1 and IOA2. Part of U15 is used to buffer the external I/O enable signal, EXTSEL-. When the external I/O is selected and U16 enabled, internal bus buffer U30 is disabled via U12-11.

3.5 BLOOD PRESSURE MEASUREMENT

The mechanical assemblies are discussed first, followed by a general description of the measurement cycle. The four parts of the cycle (inflation, deflation, data acquisition, and data processing) are then discussed in more detail.

3.5.1 The Pneumatic Assembly

The pneumatic assembly consists of a compressor pump, accumulator (or pressure reservoir), pressure sensor (located on the logic/analog board), leaker valve, dump valve, overpressure switch, and transition board. The mechanical assemblies are described in the following paragraphs.

a. Compressor Pump

The pump inflates the pressure cuff. It is a diaphragm type compressor powered by a stroke from a small crankshaft and connecting rod driven by a 12 VDC motor.

b. Accumulator

The accumulator (or reservoir), provides a minimum air capacity of the pneumatic system. Without the reservoir, too small a volume of air could cause the cuff to deflate in an erratic manner.

c. Pressure Sensor (Transducer)

The sensor converts air pressure to an electrical signal that is proportional to cuff pressure. This signal is used in two ways. First, it is used to enable the CPU to linearly deflate the cuff. Second, this signal, modulated by the varying blood pressure in the artery, is used in making a blood pressure determination.

d. Leaker Valve

This is a reed-type air valve. Under CPU control, the leaker deflates the cuff at a linear rate of 5 mmHg/sec or 2.5 mmHg/sec, depending on the operating mode and pressure signal characteristics.

e. Dump Valve

This valve is normally an open valve and has several functions. Between determinations, this open valve allows the cuff pressure to bleed to zero. When the instrument pumps up, this valve closes and remains closed during controlled cuff deflation, then opens at the end of the data-taking routine. The exception to this mode of operation is that the valve is forced open when the overpressure switch is tripped or other sections of the failsafe circuit is activated.

f. Overpressure Switch

This safety switch is adjusted to trip if the system (cuff) pressure reaches 350 to 430 mmHg due to a malfunction of the control circuits. When tripped, the leaker and dump valves are forced open, and the pump motor is disabled.

g. Transition Board

The transition board serves as a "junction box" for the electrical components on the pneumatic assembly.

3.5.2 The Measurement Cycle

A blood pressure measurement is taken as described in the following paragraphs.

a. Inflation

On signal from the START/RESET switch, or automatic timer, the CPU starts the pump via serial output data (SOD) signal to inflate the cuff. Pressure in the cuff is monitored by the pressure sensor and reported back to the CPU via the A/D converter. The CPU stops the pump when the user-selected cuff pressure is reached.

b. Deflation

After a moment for the heat of compression to equilibrate, and to check for leaks, the cuff is deflated at a constant rate, and data is collected from the microphone mounted in the cuff and from the pressure sensor.

c. To deflate the cuff, the CPU uses a deflation algorithm which controls the rate of deflation. Under control of the algorithm, the D/A converter becomes a variable negative current source, subtracting current from the pressure sensor output.

d. As each new value from the deflation algorithm is downloaded into the D/A converter, the current subtracted by the D/A converter steps down (i.e., less and less current is subtracted from the pressure sensor output). The current is subtracted at the input node to an error amplifier.

e. An error amp senses the remaining (or "difference") current. At each step in the deflation algorithm, the error amp senses the residual difference between the current subtracted by the D/A converter and the current supplied by the pressure sensor. The difference is amplified (with a gain of about 1:60), inverted, and fed into the leaker control circuit as a voltage.

f. Each step decrease in negative current at the D/A converter leads the pressure in the cuff lower by creating a positive difference current that is inverted and drives open the leaker valve to maintain the 5 mm/sec deflation rate. The pressure in the cuff is lead downward in a smooth, linear deflation curve by rapid step changes in the D/A current drain.

g. Data Acquisition

During deflation, data is collected. Three signals are digitized and stored for processing. The absolute pressure signal (APS) from the pressure sensor, the relative pressure signal (RPS) output from the pressure error amp, and the output from the microphone amplifier signal (MCS) are read by the A/D converter to the CPU. The CPU strobes these three signals every 2 milliseconds during a measurement cycle. The data is partially processed and stored in RAM for final processing at the end of the measurement cycle.

As shown in figure 3-11, the APS has a constant negative slope during deflation, and is digitized in coarse, 2 mmHg steps. The RPS and MCS respond to the very small voltage changes associated with pulse in the artery.

h. Data Processing

At the completion of the measurement cycle, the digital signals stored in RAM are processed. The software flags certain patterns associated with pulse, systole and diastole. Absolute pressure readings at systole and diastole are recalled and reported as systolic and diastolic blood pressure. Pulse in heart beats per minute is calculated by a simple algorithm.

3.5.3 Inflation Control (figure 3-12)

The pump driver circuit controls inflation of the blood pressure cuff. Cuff inflation is initiated by the CPU through serial I/O port SOD.

To inflate the cuff, the CPU drives the SOD port HI, causing Q118 on the power regulator board to be turned on via emitter follower Q1; thus turning on Q116 on the power regulator board to drive the pump motor. Air flows into the cuff through the umbilical cord connected to the front panel receptacle.

Both Q115 and Q116 must be on for battery voltage to be switched to the pump. Q115 is normally turned on constantly. It is part of the failsafe system and is a redundant switch to back-up Q116. The state of Q115 is monitored via U104-12 by the failsafe I/O port on the logic board. The pump drive is monitored via U104-15 by the failsafe I/O port on the logic board. U104 is on the power regulator board.

When the pump motor is started, the CPU issues commands to close the leaker and dump valve. Q9 is driven by signal LSO from U42 pin 15 to completely close the leaker during inflation and to hold until start of deflation.

The CPU reads the pressure setting from the front panel selector and the cuff pressure signal from the pressure sensor. When the desired cuff pressure is reached, the motor drive circuit is disconnected. The system is put on hold for five seconds to allow the air pressure to reach equilibrium and to check for leaks. Then a deflation cycle begins.

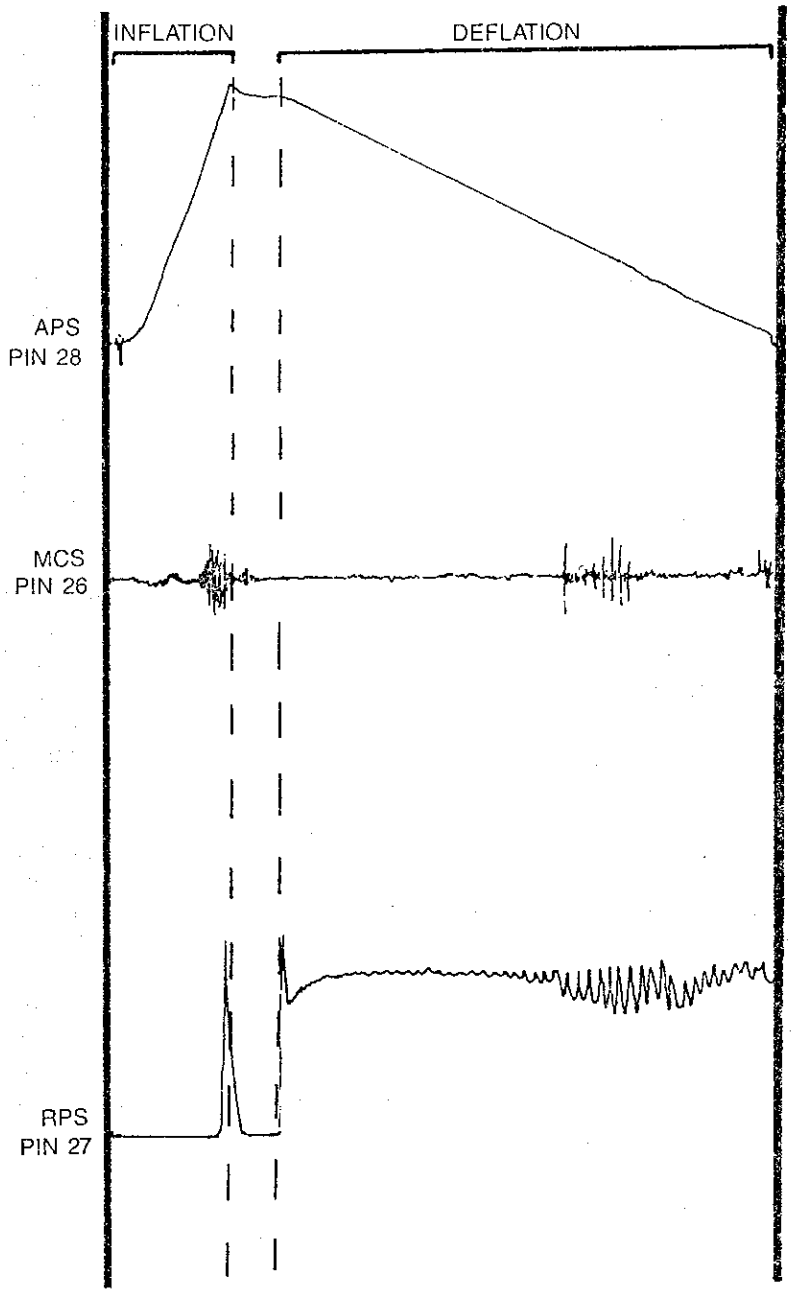


Figure 3-11. Sample Data From APS and RPS Inputs to A/D Converter

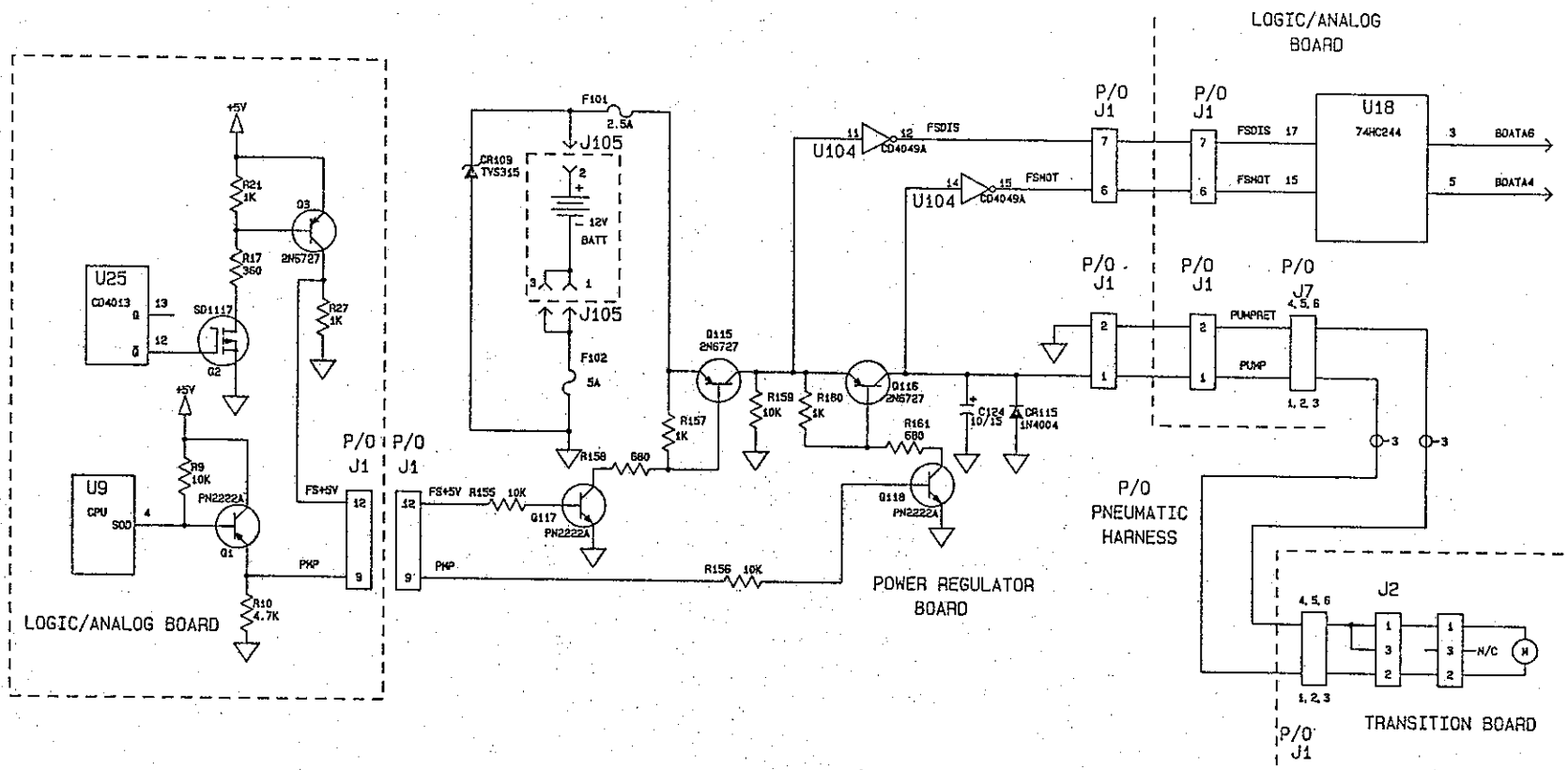


Figure 3-12. Pump Driver

3.5.4 Deflation Control (figure 3-13)

The deflation control circuit consists of several parts: the pressure sensor and error amplifier U50, the leaker driver and leaker valve, and the pneumatic control port and D/A converter U43. Taken together, these components form a closed loop with negative feedback.

During deflation, the CPU continually updates the required cuff pressure to U43. The D/A analog output is compared with the actual cuff pressure at U50. The difference between the required and actual pressure controls the leaker's orifice, maintaining the proper deflation rate.

D/A analog output is a variable negative current. The source for the negative current is a -12V power supply on the power regulator board (J2-15).

a. Pneumatic Control Port (U42) and D/A Converter (U43)

The pneumatic control port latches cuff deflation data loaded into it by the CPU.

The pneumatic control port also issues a HI at PC3 to start each A/D converter conversion cycle. Pressure and microphone data are collected at 2 ms intervals, as described in section 3.5.5.

The D/A converter is a 12-bit device. Data to U43 is latched by the pneumatic control port and provided as a 12-bit parallel word.

The D/A converter outputs a negative current (PREF). The analog reference current output at any time in the cuff deflation cycle is a function of the cuff deflation data provided by the CPU. R117 (BALANCE) is a potentiometer used to trim the D/A output.

b. Pressure Sensor and Error Amplifier

The pressure sensor and amplifier circuit U47, U48, U49, and U45 outputs a voltage corresponding to the pressure in the cuff, which is transformed by R101 into a current that drives error amplifier U50-1 (figure 3-16).

The negative reference current (PREF) from the D/A converter is added to the pressure sensor output at R101, and the error current is amplified by error amp U50-1. The error current corresponds to the difference between the expected analog value from the cuff deflation algorithm and the actual current value from the pressure sensor. This error signal is used to modulate the leaker valve via the leaker driver circuit.

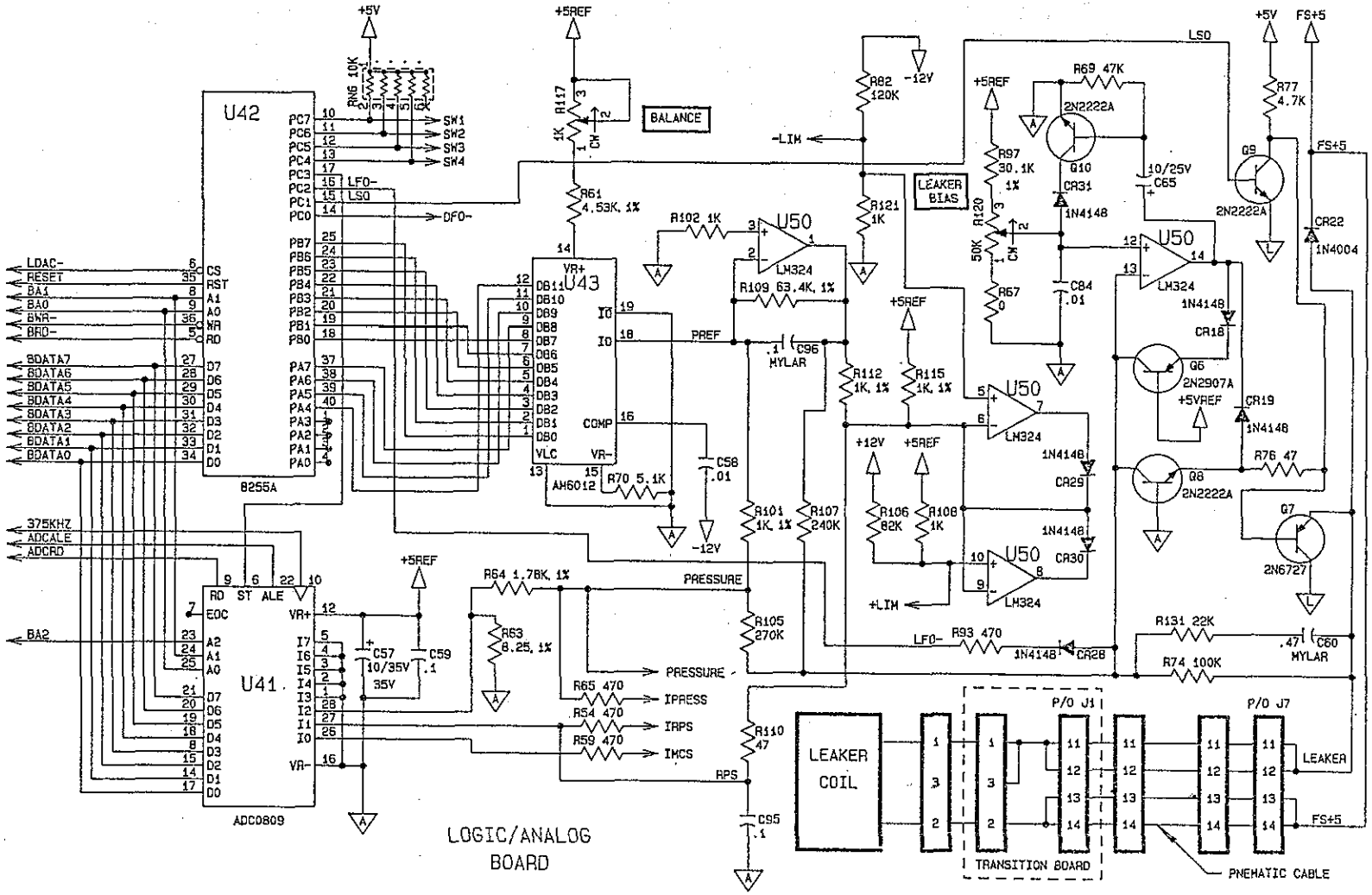


Figure 3-13. Data Acquisition and Deflation Control Loop

c. Leaker Valve

The leaker valve contains a magnetic core and coil. When current is applied to the leaker coil, the valve is drawn closed in proportion to the amount of current applied. When the current is removed, a spring opens the valve.

d. Leaker Driver (Figure 3-13)

The leaker driver consists of U50 (pins 12, 13, and 14), Q6, Q7, Q8, Q9, Q10, and associated components. The error signal from U50 pin 1, is applied through R107 to error amp U50 pin 13 inverting input. U50 pin 14 output then drives Q7, an emitter-follower current booster, via CR19 and R76. This voltage is applied to the leaker coil, opening or closing the leaker valve as required to zero the error current via the pneumatic pressure path to the pressure sensor. CR22 clips inductive spikes from the leaker coil.

R74, R131, and C60 form a negative feedback network around U50-14 and Q7. Q10 and associated components form a unidirectional slow-rate limiter to control the response of the leaker to arterial pressure pulses. Q6, Q8, CR18, and CR19 serve as bounds to prevent saturating the leaker driver stage.

An adjustable bias from R120 is injected into the loop at U50 pin 12 to compensate for variations among different leakers. This bias conditions the error signal to suit the leaker characteristics.

A sample of the pressure signal is also applied to the leaker driver through R105 to compensate the leaker at low pressure.

The pneumatic control port issues LFO- to force the leaker completely open (Q7 is off) at the end of a blood pressure measurement cycle.

e. Dump Valve (figure 3-14)

The pneumatic control port issues DFO- to open the dump valve and rapidly deflate the cuff at the end of each measurement cycle (DFO- = LO). U39 pins 2, 6, and 10, buffer DFO- to drive Q14. Q14 is the main switch, with Q12 being the backup switch which opens the valve in the event of a failsafe failure. U28 pins 12 and 15 is a level shifter which furnishes the failsafe I/O port with the dump valve control status.

3.5.5 Data Acquisition and Processing (figures 3-15 and 3-16)

a. A/D Converter

Every 2 ms during the measurement cycle, the CPU strobes all three of the A/D converter's data channels. The microphone channel (MCS) and the two pressure channels (APS and RPS) are converted to 8-bit binary and loaded onto the buffered data bus by the CPU.

The CPU accesses the A/D converter at every time base interrupt with this sequence of operations:

- read previously converted value (ADCRD = HI),
- load next multiplexer channel to convert (ADCALE = HI),
- and start conversion (PC3 = HI).

Conversion control (start conversion) is accomplished through pneumatic control port U42 pin 17 (PC3). This line is held high about 25 µs to start a conversion. A new conversion occurs every 683 µs.

b. +5V Reference

A +5V reference voltage is derived from a 1.24V reference diode VR1. An amplifier with a gain of four, consisting of U45B, VR2, R73, and R66 raises the reference diode voltage to about 5 volts. VR2 is a current booster.

+5V reference is used as a reference for the pressure sensor, D/A and A/D converter, and failsafe on the logic/analog board.

c. Microphone Channel (figure 3-15)

The microphone channel is used to amplify and condition the microphone signal prior to applying it to the A/D converter.

U46-14 is a high input impedance preamplifier with the microphone signal applied to the noninverting input. R94 and R95 set the stage gain to about 4.3. U46-1 is a low-pass filter with a roll-off at about 60 Hz. This stage has a gain of 5.6, set by R90 and R71. The output of this stage, labeled MCS (U46 pin 1), drives input channel zero of the A/D converter (U41 pin 26). Voltage divider R57 and R56 set the quiescent point of MCS to about one-half scale at the A/D to accommodate the bipolar microphone signal. U46-7 and U46-8 form an active clamp to prevent microphone signal excursions from exceeding

the input voltage limits of the A/D converter. If MCS begins to go more negative than -LIM, U46-7 will swing negative, forward biasing CR12, clamping the signal at U46-2. If MCS begins to go more positive than +LIM, U46-8 will swing positive, forward biasing CR13, clamping signal at U46 pin 2.

d. Pressure Channel (figure 3-16)

U44, Q13, R75, and reference diode VR1 form a current source of 1.5 milliamperes to provide excitation to the pressure sensor P1. Q13 collector provides the 1.5 mA current to pin 5. This current flows through the sensor to pin 6 causing a voltage drop across R75 which is equal to the voltage at VR1, about 1.24 volts. If the voltage across R75 should differ from that at VR1, U44 will amplify the difference, changing the bias at Q13 base in such a direction as to adjust the current from Q13 collector, through the sensor, to cause the voltage drop across R75 to match the reference voltage from VR1.

U47, U48, U49, and associated components are a differential instrumentation type amplifier which amplifies output from pins 4 and 10 of the sensor to a level of 12 millivolts per mmHg. R119 (SPAN) is a gain adjustment which compensates for variations in output between different pressure sensors.

Two pressure signals are digitized. APS is the conditioned full scale pressure output of the pressure sensor. RPS is a relative pressure output from error amp U50-1.

- APS. U45-1 buffers the output of the instrumentation amplifier. The networks consisting of R78 and R80 and R118 and R116 and R87 are used to cancel the zero pressure offset voltage of the pressure sensor.

  The pressure signal is fed to R101 and R105 of the deflation control system, to the failsafe test connector J5 pin 27 via R65, and to the A/D converter (U41 pin 28) through resistor network R64 and R63.

  R64 and R63 are a voltage divider to scale the pressure signal to about 9.9 millivolts per mmHg to allow the A/D converter to digitize 1 count per 2 mmHg of pressure.

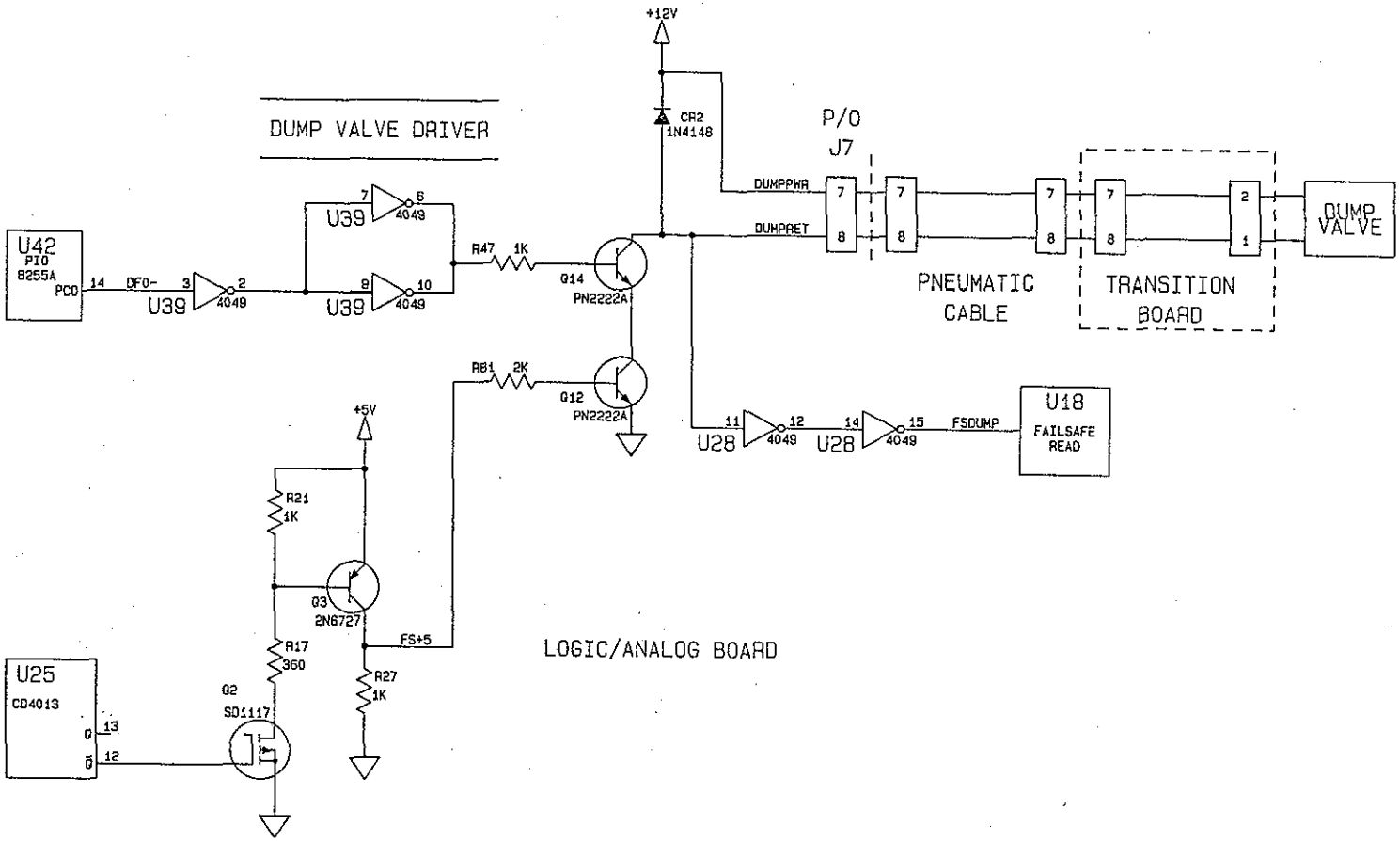


Figure 3-14. Dump Valve Driver Circuit

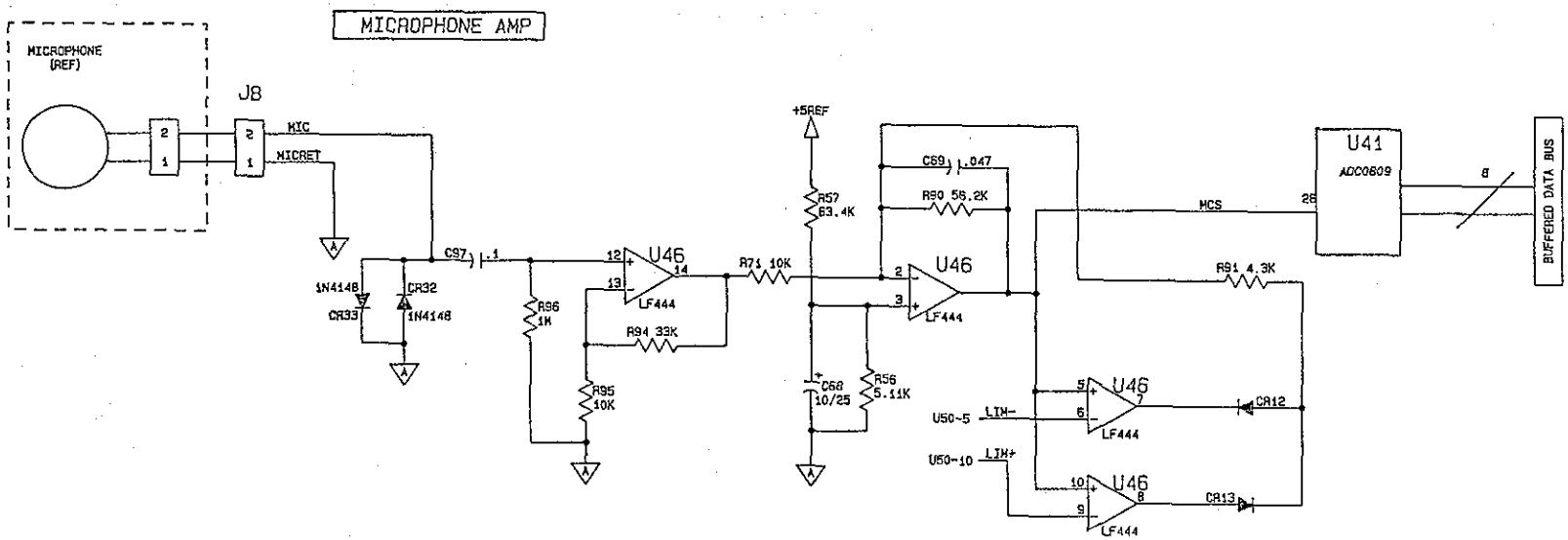


Figure 3-15. Microphone Channel